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Technology for Large Space Systems

A Special
Bibliography
with Indexes

NASA SP-7046(05)

July 1981

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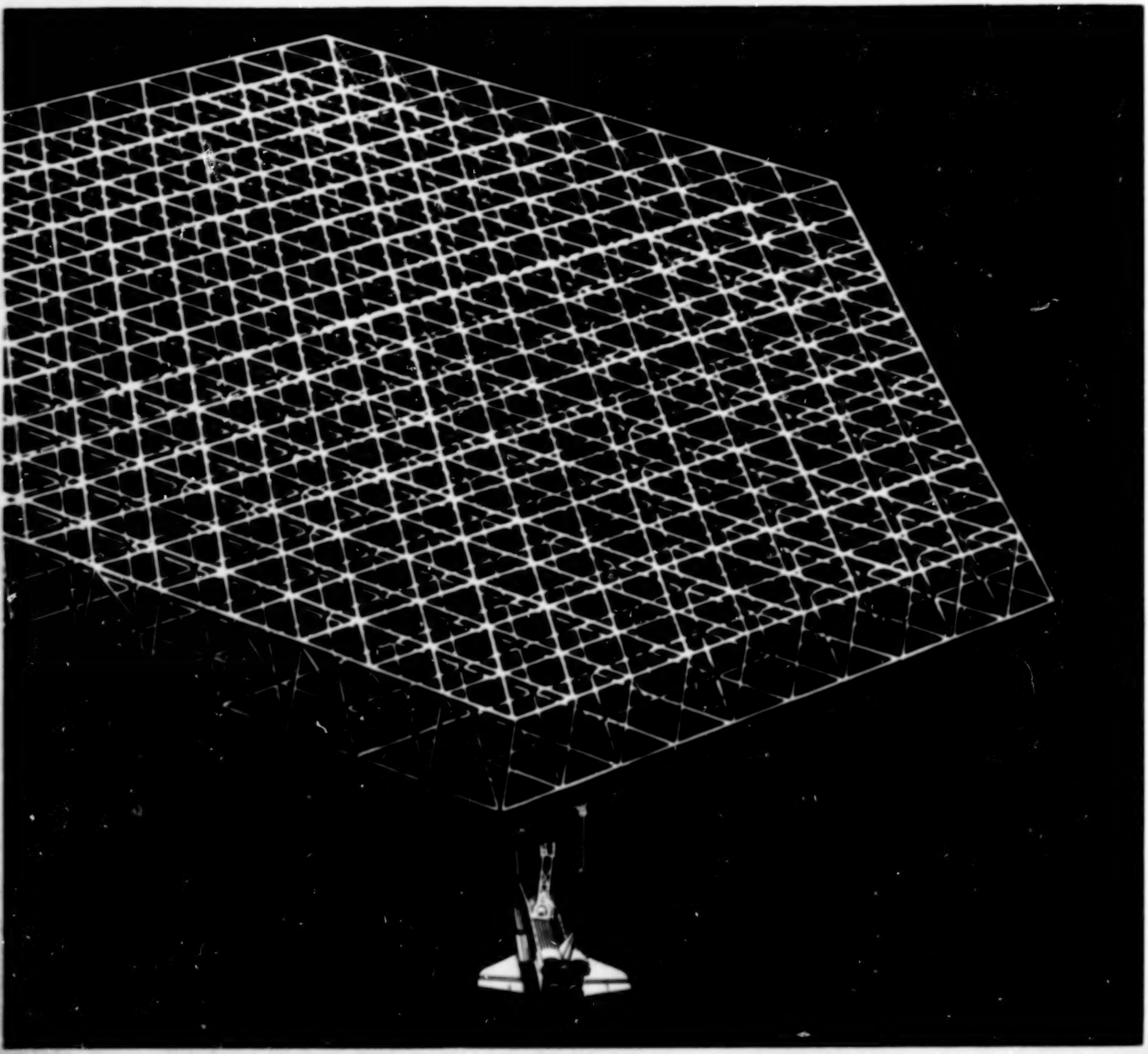

NASA SP-7046(05)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Special Bibliography With Indexes

Supplement 5

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced between January 1, 1981 and June 30, 1981 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Branch 1981
National Aeronautics and Space Administration
Washington, DC

I

This Supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, at the price code A06 ($11.00 domestic; $22.00 foreign).

INTRODUCTION

This special bibliography is designed to be helpful to the researcher and manager engaged in developing technology within the discipline areas of the Large Space Systems Technology (LSST) Program. Also, the designers of large space systems for approved missions (in the future) will utilize the technology described in the documents referenced herein.

This literature survey lists 298 reports, articles and other documents announced between January 1, 1981 and June 30, 1981 in *Scientific and Technical Aerospace Reports (STAR)* and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define specific missions that will require large space structures to achieve their objectives. The methods of integrating advanced technology into system configurations and ascertaining the resulting capabilities is also addressed.

A wide range of structural concepts are identified. These include erectable structures which are earth fabricated and space assembled, deployable platforms and deployable antennas which are fabricated, assembled, and packaged on Earth with automatic deployment in space, and space fabricated structures which use pre-processed materials to build the structure in orbit.

The supportive technology that is necessary for full utilization of these concepts is also included. These technologies are identified as Interactive Analysis and Design, Control Systems, Electronics, Advanced Materials, Assembly Concepts, and Propulsion. Electronics is a very limited field in this bibliography, primarily addressing power and data distribution techniques.

This issue of the bibliography will also contain citations to documents dealing primarily with the Solar Power Satellite System (SPS) as will subsequent issues.

The reader will not find references to material that has been designated as "limited" distribution or security classified material. These types of documents will be identified by the LSST Program Office, and a separate listing will be distributed to selected recipients.

A Flight Experiments category and a General category complete the list of subjects addressed by this document.

The selected items are grouped into eleven categories as listed in the Table of Contents with notes regarding the scope of each category. These categories were especially selected for this publication and differ from those normally found in *STAR* and *IAA*.

Each entry consists of a standard bibliographic citation accompanied by an abstract where available. The citations and abstracts are reproduced exactly as they appeared originally in *STAR* and *IAA* including the original accession numbers from the respective announcement journals. This procedure accounts for the variation in citation appearance.

Under each of the eleven categories, the entries are presented in one of two groups that appear in the following order:

1) *IAA* entries identified by accession number series A81-10,000 in ascending accession number order;
2) *STAR* entries identified by accession number series N81-10,000 in ascending accession number order.

After the abstract section there are five indexes – subject, personal author, corporate source, contract number, and report/accession number

AVAILABILITY OF CITED PUBLICATIONS

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All publications abstracted in this Section are available from the Technical Information Service, American Institute of Aeronautics and Astronautics, Inc. (AIAA), as follows. Paper copies of accessions are available at $7.00 per document up to a maximum of 40 pages. The charge for each additional page is $0.25. Microfiche[1] of documents announced in *IAA* are available at the rate of $3.00 per microfiche on demand, and at the rate of $1.25 per microfiche for standing orders for all *IAA* microfiche. The price for the *IAA* microfiche by category is available at the rate of $1.50 per microfiche plus a $1.00 service charge per category per issue. Microfiche of all the current AIAA Meeting Papers are available on a standing order basis at the rate of $1.50 per microfiche.

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Includes computerized technology design and development programs, dynamic analysis techniques, thermal modeling, and math modeling. 7

03 STRUCTURAL CONCEPTS

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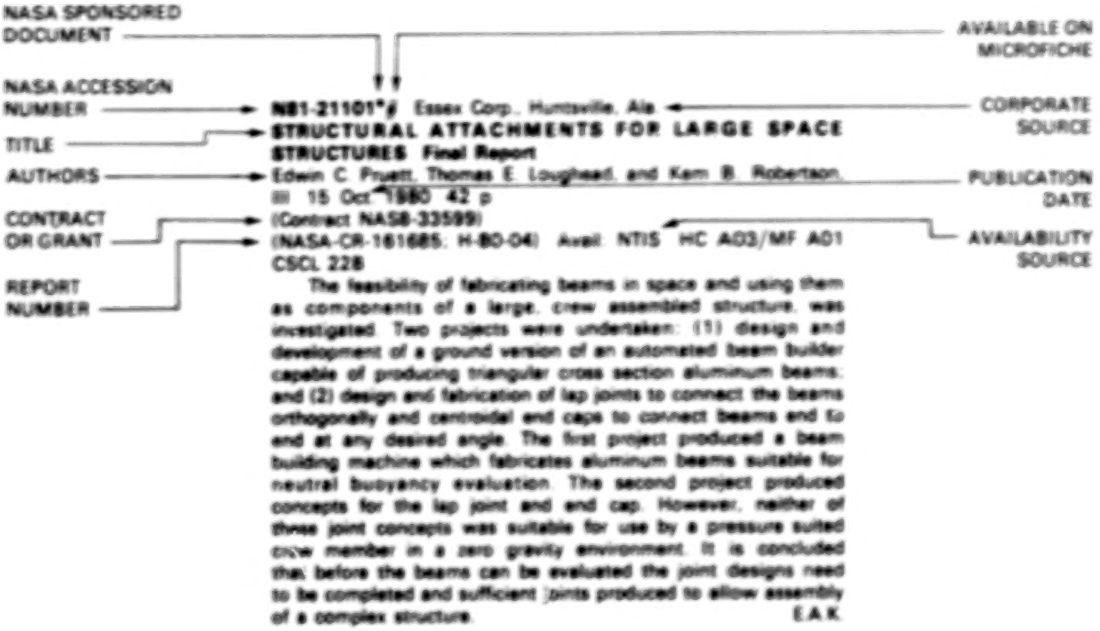
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N81-21101*# Essex Corp., Huntsville, Ala.
STRUCTURAL ATTACHMENTS FOR LARGE SPACE STRUCTURES Final Report
Edwin C. Pruett, Thomas E. Lougheed, and Kem B. Robertson, III 15 Oct. 1980 42 p
(Contract NAS8-33599)
(NASA-CR-161685; H-80-04) Avail: NTIS HC A03/MF A01 CSCL 22B

The feasibility of fabricating beams in space and using them as components of a large, crew assembled structure, was investigated. Two projects were undertaken: (1) design and development of a ground version of an automated beam builder capable of producing triangular cross section aluminum beams; and (2) design and fabrication of lap joints to connect the beams orthogonally and centroidal end caps to connect beams end to end at any desired angle. The first project produced a beam building machine which fabricates aluminum beams suitable for neutral buoyancy evaluation. The second project produced concepts for the lap joint and end cap. However, neither of these joint concepts was suitable for use by a pressure suited crew member in a zero gravity environment. It is concluded that before the beams can be evaluated the joint designs need to be completed and sufficient joints produced to allow assembly of a complex structure. E.A.K.

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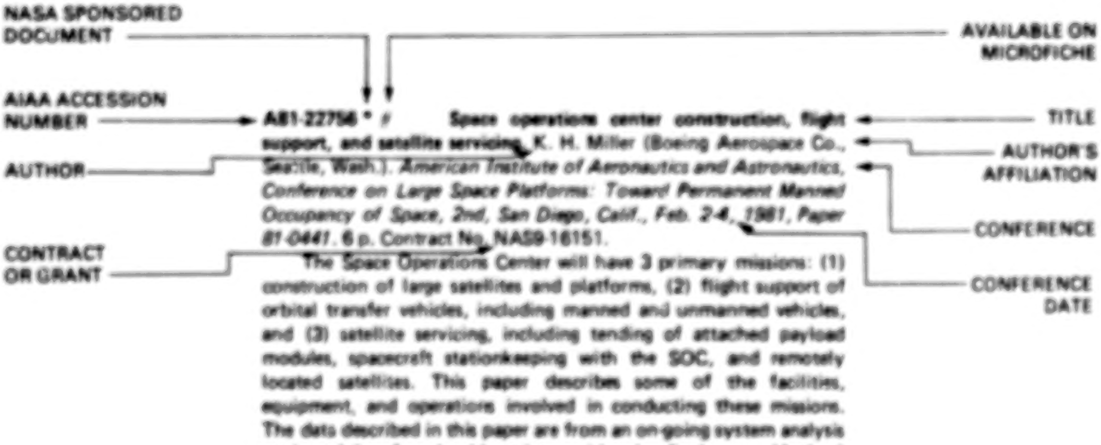
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A81-22756 * # **Space operations center construction, flight support, and satellite servicing.** K. H. Miller (Boeing Aerospace Co., Seattle, Wash.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0441.* 6 p. Contract No. NAS9-16151.

The Space Operations Center will have 3 primary missions: (1) construction of large satellites and platforms, (2) flight support of orbital transfer vehicles, including manned and unmanned vehicles, and (3) satellite servicing, including tending of attached payload modules, spacecraft stationkeeping with the SOC, and remotely located satellites. This paper describes some of the facilities, equipment, and operations involved in conducting these missions. The data described in this paper are from an on-going system analysis study and therefore should not be considered as final. (Author)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Special Bibliography

JULY 1981

01
SYSTEMS

Includes mission requirements, focus missions, conceptual studies, technology planning, and systems integration.

A81-13191 * **Space Operations Center - A concept analysis.** *British Interplanetary Society, Journal (Space Technology)*, vol. 33, Dec. 1980, p. 419-426.

The Space Operations Center (SOC) which is a concept for a Shuttle serviced, permanent, manned facility in low earth orbit is viewed as a major candidate for the manned space flight following the completion of an operational Shuttle. The primary objectives of SOC are: (1) the construction, checkout, and transfer to operational orbit of large, complex space systems, (2) on-orbit assembly, launch, recovery, and servicing of manned and unmanned spacecraft, (3) managing operations of co-orbiting free-flying satellites, and (4) the development of reduced dependence on earth for control and resupply. The structure of SOC, a self-contained orbital facility containing several Shuttle launched modules, includes the service, habitation, and logistics modules as well as construction, and flight support facilities. A schedule is proposed for the development of SOC over ten years and costs for the yearly programs are estimated.

A.C.W.

A81-18229 **Lunetta system analysis.** K. A. Ehricke (Space Global Co., La Jolla, Calif.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-11.* 56 p. 10 refs.

The results of a Lunetta Space Light system analysis are presented. Lunetta orbiting reflectors are the only earth-related energy structures of socio-economic importance realizable in the 1980s, because they are relatively small and light, although they are larger than any structure built so far in space. They represent a stepping stone in space industrialization with potentially important applications, particularly as far as assistance to higher local food production in many parts of the world are concerned. Lunetta applications are summarized and the favorable environmental characteristics of the system shown. A comprehensive number of conflicting requirements and parameters, necessitating numerous trade-offs, are discussed.

(Author)

A81-18250 **The external tank as a large space structure construction base.** N. J. Witek (Martin Marietta Aerospace, New Orleans, La.) and T. C. Taylor (Taylor and Associates, Los Angeles, Calif.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-41.* 15 p.

The development of LSS (large space structures) construction will require the transportation of 3500 lbs of beam-fabrication test equipment to and from orbit to establish an early orbital base. The ET (external tank) through the addition of an ACC (aft cargo compartment), can fulfill this space mission and be cost-effective. The ACC, a simple shell 27.5 feet in diameter and up to 24.5 feet in length, has a volume of 13,364 cubic feet, which is 26% greater than that of the orbiter's cargo bay. Elimination of the ET jettison maneuver allows a more lofting trajectory and provides additional orbiter performance as a result of increased thrust from ET residual fuel. An ET-derived construction base with an ACC could house a 25 kW power module, a universal beam-fabrication test fixture, a remote manipulator arm, and a storage platform for test equipment. The ACC and the hydrogen tank could provide together 70,000 cubic feet of shirtsleeve hangar volume, making the storage of a 410-foot diameter antenna possible. Finally, it is noted that the external tank's empty weight of 78,000 lbs and its gravity gradient mode in orbit can simplify certain structural dynamic problems.

R.S.

A81-20762 * # **Science and Applications Space Platforms - A NASA overview.** C. E. DeSanctis (NASA, Washington, D.C.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0339.* 8 p. 7 refs.

An overview of past, present, and future activities relating to space platforms is presented, with emphasis placed on implementation of the initial platform. It is noted that the challenge at present is to define an initial system that can accommodate high priority science, that possesses the capability of doing multi-discipline science, and that demonstrates on-orbit servicing and payload exchange through use of the Shuttle. The evolution of the Science and Applications Space Platform (SASP), which will provide significantly more time on-orbit for instrument operations without increasing Space Shuttle orbiter time on-orbit, is traced. The importance of completing all required activities to support a new start for the SASP in fiscal year 1983 is stressed. While the initial SASP will support only a limited set of investigations, the program will evolve by replication, upgrading, or the development of new systems to support a broader and generally more demanding set of system requirements.

C.R.

A81-20786 # **Experiment design considerations for space platforms.** R. B. Crisman and R. L. Wax (TRW Defense and Space Systems Group, Redondo Beach, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0344.* 7 p.

One of the basic purposes of the Science and Applications Space Platform (SASP) is to provide instruments originally developed for Spacelab with an opportunity for much longer on-orbit operating times than is possible on Spacelab. Therefore, a major factor in the SASP design is to maintain the SASP/instrument interface as similar as possible. In this paper each interface area (structures, electric power, etc.) is considered separately and any new analyses of modifications required for adaptation are identified. Any changes that are necessary from an operational standpoint are identified also. The analysis shows that the five instruments investigated, which were originally designed for Spacelab could be adapted for flight on SASP with minor modifications. Two of these could operate only 30 days after each 3 month orbital refurbishment unless somewhat more significant modifications were made. The single instrument investigated which was not originally designed for Spacelab would require extensive modifications. (Author)

A81-22755 # **Mission utility influences on Space Operations Center design.** G. R. Woodcock (Boeing Aerospace Co., Seattle, Wash.) and H. F. Brose (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0440.* 11 p. 6 refs.

A Space Operations Center (SOC) providing support for mission operations in low earth orbit in the next two decades is discussed. Three primary steps, flight support, construction and spacecraft servicing are covered in detail based on mission models. Also discussed are SOC-Space Transportation System (Shuttle) interrelationships, configuration factor selection, crew accommodations and crew life support systems. A possible option of placement of a SOC in geosynchronous orbit before the year 2000 is briefly covered. N.D.

A81-22756 * # **Space operations center construction, flight support, and satellite servicing.** K. H. Miller (Boeing Aerospace Co., Seattle, Wash.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0441.* 6 p. Contract No. NAS9-16151.

The Space Operations Center will have 3 primary missions: (1) construction of large satellites and platforms, (2) flight support of orbital transfer vehicles, including manned and unmanned vehicles, and (3) satellite servicing, including tending of attached payload modules, spacecraft stationkeeping with the SOC, and remotely located satellites. This paper describes some of the facilities, equipment, and operations involved in conducting these missions. The data described in this paper are from an on-going system analysis study and therefore should not be considered as final. (Author)

A81-22758 * # **Critical requirements for the design of large space structures.** J. M. Hedgepeth (Astro Research Corp., Carpinteria, Calif.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0443.* 12 p. 11 refs. Contract No. NAS1-15347.

The requirements for the design of a large space structure which will be deployed, erected, assembled or fabricated in space are delineated in terms of operational loads, stiffness requirements, structure-control interaction, deformations, precision requirements and member slenderness. Design examples for a truss antenna reflector, interorbit propulsion loads and free-flying solar reflectors are given. It is concluded that the demand for dimensional accuracy and stability form the primary requirements. L.S.

A81-22763 * # **Utility of and technology for a space central power station.** P. F. Holloway and L. B. Garrett (NASA, Langley Research Center, Hampton, Va.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0449.* 23 p. 31 refs.

The technological and economic impact of a large central power station in earth orbit on the cost and performance of future spacecraft and their orbital-transfer systems are examined. The three systems considered for the space central power station are a photovoltaic array, a direct nuclear-pumped laser and a direct solar-pumped laser. It is noted that laser transmitters/receivers will be required to make central power stations feasible. While the remote transmission of power solely to meet the needs of earth orbiting satellites will not be cost-effective in the near future, the remote-power transmission for propulsion of orbital-transfer vehicles promises many cost benefits. L.S.

A81-22767 * # **Science and applications space platform.** M. Nein (NASA, Marshall Space Flight Center, Advanced Systems Group, Huntsville, Ala.) and F. Runge (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0458.* 10 p.

The concept for the Platform/Power System combination (supported by Shuttle visits) is presented from the NASA-sponsored Phase A study. The combination will cost-effectively free-fly small groups of unmanned low-earth payloads which have common accommodation needs. A manned support module and power system can provide elemental and growth capability for 3-6 month missions. The configuration and payload accommodations of the combination systems are reviewed and schematized in detail. Flight operations for the payload science management will include the conduct of science operations, the monitoring of instrument performance, verification of the science data and the maintenance of the science mission plan. L.S.

A81-22769 # **A commercial Construction Base using the External Tank.** T. C. Taylor (Taylor and Associates, Inc., Los Angeles, Calif.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0460.* 12 p. 10 refs.

The construction of Large Space Structures in low earth orbit will someday be a mature commercial industry. As this industry emerges, it will go through many phases as the Beam Machine and other hardware is developed and specific platform structure designs emerge. This development time can be shortened by the early deployment of a Construction Base which, first, supports this development period, and second, expands incrementally into a commercial facility as the low earth orbit construction market develops. Conceptually, the External Tank (ET)-derived Construction Base offers a variety of advantages through the use of the Aft Manned Compartment (AMC) attached to the rear of an ET taken into orbit. (Author)

A81-22771 * # **The Manned Space Platform as an evolutionary means to achieve a permanent manned orbital operations facility.** J. M. Schwartz and J. D. Hitchey (NASA, Marshall Space Flight Center, Huntsville, Ala.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0462.* 12 p. 11 refs.

An evolutionary approach to permanently manned on-orbit facilities is discussed, and it is noted that the Science and Applications Manned Space Platform, which is the first step in this evolution, can be based primarily on existing and currently planned hardware. It is shown how by upgrading the systems capabilities of the Spacelab modules, the platform can be reconfigured to provide a permanent manned research and operations facility. The facility can grow in size and capability to accommodate increases in user requirements, more experiment modules, and larger crews and to provide additional power and heat rejection. It is noted that the Growth-Permanently Manned Facility can be used for science activities and/or to support various operations functions such as space construction, servicing and maintaining space systems, and vehicle assembly. C.R.

A81-22772 * # **Space operation center - The key to space industrialization.** S. H. Nassiff (NASA, Johnson Space Center, Program Development Office, Houston, Tex.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0463.* 9 p.

The concept of a Shuttle-serviced Space Operations Center (SOC) and SOC program development are reviewed. The subjects discussed include: projected operational support capabilities, SOC elements and subsystems, and supporting research and technology.
V.L.

N81-12133*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION FOLLOW-ON STUDY. VOLUME 2A: TECHNICAL TASK 2 LSST SPECIAL EMPHASIS Final Report
Sep. 1980 151 p refs
(Contract NAS8-33527)
(NASA-CR-161587; GPP-79-010-Vol-2A) Avail: NTIS HC A08/MF A01 CSCL 22B

The results of the Large Space Systems Technology special emphasis task are presented. The task was an analysis of structural requirements deriving from the initial Phase A Operational Geostationary Platform study.
T.M.

N81-13075*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
CONCEPTUAL DESIGN STUDY SCIENCE AND APPLICATION SPACE PLATFORM SASP. VOLUME 1: EXECUTIVE SUMMARY
Fritz C. Runge Oct. 1980 27 p refs 3 Vol.
(Contract NAS8-33592)
(NASA-CR-161615; MDC-G8248-Vol-1) Avail: NTIS HC A03/MF A01 CSCL 22B

The system design philosophy applied in the development of this platform concept is summarized. The system is to provide for simple, low cost, initial capability of accommodating Spacelab payloads that are modified for long duration flight. The supporting research and technology are also summarized.
T.M.

N81-13076*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
CONCEPTUAL DESIGN STUDY SCIENCE AND APPLICATIONS SPACE PLATFORM SASP. VOLUME 2: TECHNICAL REPORT
Fritz C. Runge Oct. 1980 482 p refs 3 Vol.
(Contract NAS8-33592)
(NASA-CR-161616; MDC-G8248-Vol-2) Avail: NTIS HC A21/MF A01 CSCL 22B

The platform payload accommodations, configuration drivers, and power system are described in detail. The platform design was analyzed and is presented. Demonstration tests are described and the results are reported.
T.M.

N81-13077*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
CONCEPTUAL DESIGN STUDY SCIENCE AND APPLICATIONS SPACE PLATFORM SASP. VOLUME 3: PROGRAMMATICS, COST AND SCHEDULE REPORT
Fritz C. Runge Oct. 1980 58 p refs 3 Vol.
(Contract NAS8-33592)
(NASA-CR-161617; MDC-G8248-Vol-3) Avail: NTIS HC A04/MF A01 CSCL 22B

Mission planning and project management methods are described. Cost estimates for the project are presented. A review of scheduling, budgeting, and facilities is also presented.
T.M.

N81-18072*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report
Jun. 1980 72 p Prepared in cooperation with Communications Satellite Corp., Clarksburg, Md.
(Contract NAS8-33527)
(NASA-CR-161647; GDC-GPP-79-006-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 22B

The results of a geostationary platform concept analysis are summarized. Mission and payloads definition, concept selection, the requirements of an experimental platform, supporting research and technology, and the Space Transportation System interface requirements are addressed. It is concluded that platforms represent a logical extension of current trends toward larger, more complex, multifrequency satellites. Geostationary platforms offer significant cost savings compared to individual satellites, with the majority of these economies being realized with single Shuttle launched platforms. Further cost savings can be realized, however, by having larger platforms. Platforms accommodating communications equipment that operates at multiple frequencies and which provide larger scale frequency reuse through the use of large aperture multibeam antennas and onboard switching maximize the useful capacity of the orbital arc and frequency spectrum. Projections of market demand indicate that such conservation measures are clearly essential if orderly growth is to be provided for. In addition, it is pointed out that a NASA experimental platform is required to demonstrate the technologies necessary for operational geostationary platforms of the 1990's.
M.G.

N81-18073*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION STUDY. VOLUME 2: TECHNICAL, BOOK 1 Final Report
Jun. 1980 210 p refs Prepared in cooperation with Communications Satellite Corp., Clarksburg, Md.
(Contract NAS8-33527)
(NASA-CR-161648; GDC-GPP-79-006-Vol-2-Bk-1) Avail: NTIS HC A10/MF A01 CSCL 22B

The initial selection and definition of operational geostationary platform concepts is discussed. Candidate geostationary platform missions and payloads were identified from COMSAT, Aerospace, and NASA studies. These missions and payloads were cataloged; classified with to communications, military, or scientific uses; screened for application and compatibility with geostationary platforms; and analyzed to identify platform requirements. Two platform locations were then selected (Western Hemisphere - 110 deg W, and Atlantic - 15 deg W), and payloads allocated based on nominal and high traffic models. Trade studies were performed leading to recommendation of selected concepts. Of 30 Orbit Transfer Vehicle (OTV) configuration and operating mode options identified, 18 viable candidates compatible with the operational geostationary platform missions were selected for analysis. Each was considered using four platform operational modes - 8 or 16 year life, and serviced or nonserviced, providing a total of 72 OTV/platform-mode options. For final trade study concept selection, a cost program was developed considering payload and platform costs and weight; transportation unit and total costs for the shuttle and OTV; and operational costs such as assembly or construction time, mating time, and loiter time. Servicing costs were added for final analysis and recommended selection.
M.G.

N81-18074*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION STUDY. VOLUME 2: TECHNICAL, BOOK 2 Final Report
Jun. 1980 413 p refs Prepared in cooperation with Communications Satellite Corp., Clarksburg, Md.
(Contract NAS8-33527)
(NASA-CR-161649; GDC-GPP-79-006-Vol-2-Bk-2) Avail: NTIS HC A18/MF A01 CSCL 22B

A selected concept for a geostationary platform is defined in sufficient detail to identify requirements for supporting research and technology, space demonstrations, GFE interfaces, costs, and schedules. This system consists of six platforms in geostationary orbit (GEO) over the Western Hemisphere and six over the Atlantic, to satisfy the total payload set associated with the nominal traffic model. Each platform is delivered to low Earth orbit (LEO) in a single shuttle flight, already mated to its LEO to GEO transfer vehicle and ready for deployment and transfer to GEO. An alternative concept is looked at briefly for comparison of configuration and technology requirements. This alternative consists of two large platforms, one over the Western Hemisphere consisting of three docked modules, and one over the Atlantic (two docked modules), to satisfy a high traffic model. The modules are full length orbiter cargo bay payloads, mated at LEO to orbital transfer vehicles (OTVs) delivered in other shuttle flights, for transfer to GEO, rendezvous, and docking. A preliminary feasibility study of an experimental platform is also performed to demonstrate communications and platform technologies required for the operational platforms of the 1990s. M.G.

N81-19075*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION STUDY. VOLUME 2: TECHNICAL, BOOK 3 Final Report
Jun. 1980 242 p Prepared in cooperation with Communications Satellite Corp., Clarksburg, Md.
(Contract NAS8-33527)
(NASA-CR-161650; GDC-GPP-79-006-Vol-2-Bk-3) Avail: NTIS HC A11/MF A01 CSCL 22B

The supporting research and technology, and space demonstrations required to support the 1990s operational geostationary platforms are identified. Also the requirements on and interfaces with the Space Transportation System hardware elements supporting the geostationary platform program, including the shuttle, orbital transfer vehicles, teleoperator, etc., are investigated to provide integrated support requirements. Finally, a preliminary evaluation of the practicability and capabilities of an experimental platform from the standpoint of technology, schedule, and cost is given. M.G.

N81-19076*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION STUDY. VOLUME 2A: APPENDIXES, BOOK 1 Final Report
Jun. 1980 380 p Prepared in cooperation with Communications Satellite Corp., Clarksburg, Md.
(Contract NAS8-33527)
(NASA-CR-161651; GDC-GPP-79-006-Vol-2A-Bk-1) Avail: NTIS HC A16/MF A01 CSCL 22B

Appendixes addressing various aspects of a geostationary platform concepts definition study are given. Communication platform traffic requirements, video conferencing forecast, intersatellite link capacity requirements, link budgets, payload data, payload assignments, and platform synthesis are addressed. M.G.

N81-19077*# General Dynamics/Convair, San Diego, Calif.
GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION STUDY. VOLUME 2A: APPENDIXES, BOOK 2 Final Report
Jun. 1980 187 p refs Prepared in cooperation with Communications Satellite Corp., Clarksburg, Md.
(Contract NAS8-33527)
(NASA-CR-161652; GDC-GPP-79-006-Vol-2A-Bk-2) Avail: NTIS HC A09/MF A01 CSCL 22B

Various investigations and support data concerning geostationary platform feasibility are presented. Servicing flight analyses, platform cost model runs, and funding spread analyses are included. In addition, investigations of the radiation environment at synchronous altitude and its effects on satellite communication are reported. M.G.

N81-19171*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN ECONOMY OF SCALE SYSTEM'S MENSURATION OF LARGE SPACECRAFT
L. J. DeRyder *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 87-104 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

The systems technology and cost particulars of using multipurpose platforms versus several sizes of bus type free flyer spacecraft to accomplish the same space experiment missions. Computer models of these spacecraft bus designs were created to obtain data relative to size, weight, power, performance, and cost. To answer the question of whether or not large scale does produce economy, the dominant cost factors were determined and the programmatic effect on individual experiment costs were evaluated. R.C.T.

N81-19174*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE PLATFORM REFERENCE MISSION STUDIES OVERVIEW
James K. Harrison *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 129-132

Avail: NTIS HC A19/MF A01 CSCL 22B

The design requirements for three major space platform systems are identified. The three were the Science and Applications Space Platform (SASP), the Geostationary Platform (GSP), and the Satellite Power System (SPS). Because the SASP and GSP were assumed to require no advanced technology for their development an advanced version of each was selected on which to base the design requirements. The SPS represented the opposite development state hence a nearer term test article was selected on which to base the requirements. The development period for these missions is estimated. M.G.

N81-19176*# General Dynamics/Convair, San Diego, Calif.
STRUCTURAL REQUIREMENTS AND TECHNOLOGY NEEDS OF GEOSTATIONARY PLATFORMS
G. R. Stone *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 149-166 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

To identify structural requirements and technology needs of the geostationary platforms, two design alternatives are analyzed with respect to utilities accommodation, interface, and strength and stiffness requirements. Alternative 1 is comprised of 6,800 kg (15,000 lb) platform modules, each delivered to low earth orbit (LEO) with an attached orbit transfer vehicle (OTV) in a single Shuttle flight, deployed, and transferred to a geostationary constellation of platforms. Alternative 2 is made up of 16,800 kg (37,000 lb) platform modules, each delivered to LEO, deployed, mated to a 2 stage OTV (delivered to LEO in two additional Shuttle flights) and transferred to GEO for docking with other modules to form a single large platform. The top candidates for deployable structure elements are the expendable truss beam and the Astromast. The beam, fabricated of graphite/epoxy with a designed coefficient of thermal expansion of zero, provides good packaging density and high strength and stiffness per unit weight. The Astromast provides the best packaging density, but lacks the strength and stiffness required for the platform payloads. A graphite/epoxy mast with the Astromast packaging density is an advancement in technology needed for optimizing the geostationary platform designs. M.G.

N81-19177*# Rockwell International Corp., Seal Beach, Calif. Satellite Systems Div.
SUMMARY OF LSST SYSTEMS ANALYSIS AND INTEGRATION TASK FOR SPS FLIGHT TEST ARTICLES
H. S. Greenberg *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 167-182 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

The structural and equipment requirements for two solar power satellite (SPS) test articles are defined. The first SPS concept uses a hexagonal frame structure to stabilize the array of primary tension cables configured to support a Mills Cross antenna containing 17,925 subarrays composed of dipole radiating elements and solid state power amplifier modules. The second test article consists of a microwave antenna and its power source, a 20 by 200 m array of solar cell blankets, both of which are supported by the solar blanket array support structure. The test article structure, a ladder, is comprised of two longitudinal beams (215 m long) spaced 10 m apart and interconnected by six lateral beams. The system control module structure and bridge fitting provide bending and torsional stiffness, and supplement the in plane Vierendeel structure behavior. Mission descriptions, construction, and structure interfaces are addressed. M.G.

N81-19180*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL ANTENNA TECHNOLOGY DEVELOPMENT

BEST DOCUMENT AVAILABLE

R. E. Freeland *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 287-294

Avail: NTIS HC A19/MF A01 CSCL 22B

Plans for evaluating, designing, fabricating, transporting and deploying cost effective and STS compatible offset wrap rib antennas up to 300 meters in diameter for mobile communications, Earth resources observation, and for the orbiting VLBI are reviewed. The JPL surface measurement system, intended for large mesh deployable antenna applications will be demonstrated and validated as part of the antenna ground based demonstration program. Results of the offset wrap rib deployable antenna technology development will include: (1) high confidence structural designs for antennas up to 100 meters in diameter; (2) high confidence estimates of functional performance and fabrication cost for a wide range of antenna sizes (up to 300 meters in diameter); (3) risk assessment for fabricating the large size antennas; and (4) 55 meter diameter flight quality hardware that can be cost effectively completed toto accommodate a flight experiment and/or application.

A.R.H.

N81-19190*# Boeing Aerospace Co., Kent, Wash.
ANTENNA SYSTEMS REQUIREMENTS DEFINITION STUDY
C. T. Goldon *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 349-356

Avail: NTIS HC A19/MF A01 CSCL 22B

A plan to use a 55m wrap rib antenna in a second generation land mobile satellite service application as a specific mission to define a large space structure technology system and its interfaces is described. The system design aims to examine the launch phase of the mission including interface with the space transportation system and the orbital transfer vehicle, and the deployment from the spacecraft of the boom, antennas, and solar panels. Methods for determining the effect of system configuration on the interfaces and of the space environment and operational events on the system and its subsystem interfaces are discussed.

A.R.H.

N81-19196*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE 1980 LARGE SPACE SYSTEMS TECHNOLOGY. VOLUME 2: BASE TECHNOLOGY
Frank Kopriver, III, comp. (Systems Management Associates, Hampton, Va.) Feb. 1981 188 p refs Second Annual Technical Review held in Hampton, Va., 18-20 Nov. 1980
(NASA-CP-2168-Vol-2; L-14219) Avail: NTIS HC A09/MF A01 CSCL 22B

Technology pertinent to large antenna systems, technology related to large space platform systems, and base technology applicable to both antenna and platform systems are discussed. Design studies, structural testing results, and theoretical applications are presented with accompanying validation data. A total systems approach including controls, platforms, and antennas is presented as a cohesive, programmatic plan for large space systems.

N81-19386*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A PRELIMINARY STUDY OF A VERY LARGE SPACE RADIOMETRIC ANTENNA
Pradeep K. Agrawal Jan. 1979 45 p refs
(NASA-TM-80047) Avail: NTIS HC A03/MF A01 CSCL 20N

An approach used to compute the size of a special radiometric reflector antenna is presented. Operating at 1 GHz, this reflector is required to produce 200 simultaneous contiguous beams, each with a 3 dB footprint of 1 km from an assumed satellite height of 650 km. The overall beam efficiency for each beam is required to be more than 90%.

Author

N81-19488*# General Dynamics/Convair, San Diego, Calif.
MODULAR REFLECTOR CONCEPT STUDY Final Contractor Report, Apr. 1979 - Feb. 1980
D. H. Vaughan Washington NASA Mar. 1981 119 p refs
(Contract NAS1-15753)
(NASA-CR-3411; GDC-ASP-79-003) Avail: NTIS HC A06/MF A01 CSCL 20K

A study was conducted to evaluate the feasibility of space erecting a 100 meter paraboloidal radio frequency reflector by joining a number of individually deployed structural modules. Three module design concepts were considered: (1) the deployable cell module (DCM); (2) the modular paraboloidal erectable truss antenna (Mod-PETA); and (3) the modular erectable truss antenna (META). With the space shuttle (STS) as the launch system, the methodology of packaging and stowing in the orbiter, and of dispensing, deploying and joining, in orbit, were studied and the necessary support equipment identified. The structural performance of the completed reflectors was evaluated and their overall operational capability and feasibility were evaluated and compared. The potential of the three concepts to maintain stable shape in the space environment was determined. Their ability to operate at radio frequencies of 1 GHz and higher was assessed assuming the reflector surface to consist of a number of flat, hexagonal facets. A parametric study was performed to determine figure degradation as a function of reflector size, flat facet size, and f/D ratio.

Author

N81-20146*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Advanced Space Programs Directorate.
SPACE PLATFORM ADVANCED TECHNOLOGY STUDY Final Report
Gene Burns Feb. 1981 75 p
(Contract NAS9-16001)
(NASA-CR-160934; MDC-G9346) Avail: NTIS HC A04/MF A01 CSCL 22B

Current and past space platform and power module studies were utilized to point the way to areas of development for mechanical devices that will be required for the ultimate implementation of a platform erected and serviced by the Shuttle/Orbiter. The study was performed in accordance with a study plan which included: a review of space platform technology; orbiter berthing system requirements; berthing latch interface requirements, design, and model fabrication; berthing umbilical interface requirements and design; adaptive end effector design and model fabrication; and adaptive end effector requirements.

T.M.

N81-21117# Consulenze Generali Roma (Italy).
STUDY ON SYNTHESIS AND CHARACTERIZATION OF LARGE SPACE SYSTEMS. PART 1: SURVEY OF MISSIONS Final Report
Carlo Arduini and Ugo Ponzi Paris ESA Apr. 1980 282 p refs 3 Vol.
(Contract ESTEC-3959/79/NL-AK)
(ESA-CR(P)-1388-Vol-1) Avail: NTIS HC A12/MF A01

Large space systems planned missions, proposals, and concepts were surveyed through NASA and industry documents and through the general literature. Large space structures (LSS) and their interfaces with other subsystems are characterized in order to establish trends and boundaries of feasibility. Particular construction problems are identified and preliminary mechanical requirements of predefined categories of LSS are provided. These categories include structural members (columns), attachments, and joints. Categories related to the configuration of various design problems are then established in reference to mission forms. These cover solar power, telecommunications, Earth sensing, astronomy, demonstration missions, and multipurpose missions.

Author (ESA)

N81-21118# Consulenze Generali Roma (Italy).
STUDY ON SYNTHESIS AND CHARACTERIZATION OF LARGE SPACE SYSTEMS. PART 2: SURVEY OF PROBLEMS Final Report
Carlo Arduini and Ugo Ponzi Paris ESA Apr. 1980 307 p 3 Vol.
(Contract ESTEC-3959/79/NL-AK)
(ESA-CR(P)-1388-Vol-2) Avail: NTIS HC A14/MF A01

Large space structures (LSS) and their interfaces with other subsystems were studied in order to identify the most important design and construction problems. Together with the presentation of the problems, analytical indexes intended to quantify LSS feasibility are introduced and discussed. The problem survey covers five main categories: (1) operational load conditions; (2) structural problems, including testing techniques; (3) control problems; (4) thermal problems; and (5) problems concomitant with orbit transfer and propulsion.
Author (ESA)

N81-21119# Consulenze Generali Roma (Italy).
STUDY ON SYNTHESIS AND CHARACTERIZATION OF LARGE SPACE STRUCTURES. PART 3: CHARACTERIZATION AND SYNTHESIS Final Report
Carlo Arduini and Ugo Ponzi Paris ESA Apr. 1980 256 p refs 3 Vol.
(Contract ESTEC-3954/79/NL-AK)
(ESA-CR(P)-1385-Vol-3) Avail: NTIS HC A12/MF A01

Indexes of technology feasibility are applied to different mission configurations in order to provide a nonempirical quantization of the realization complexity for a given large space structure (LSS). The meaning and limitations of the mission selection are considered. The indexes are recalled and summarized while their significance, their applicability and their use for generating LSS categories are explained. The characterization diagrams are presented and extensively discussed. They provide the basis for the classification which is founded on morphological as well as on functional characteristics of the systems. The characteristic families and twenty morphological/functional categories are proposed. The main mechanical requirements for each category are then logically associated to the characteristics indexes so that a table of typical technological development requirements results. The most important near term development areas, thus identified, are briefly outlined.
Author (ESA)

02
INTERACTIVE ANALYSIS AND DESIGN

Includes computerized technology design and development programs, dynamic analysis techniques, thermal modeling, and math modeling.

A81-13879 **The computer analysis of space frames with offset members.** N. Subramanian and C. G. Chettiar (Indian Institute of Technology, Madras, India). *Computers and Structures*, vol. 11, Apr. 1980, p. 297-303. 7 refs. Research supported by the Council of Scientific and Industrial Research.

The problems involved in the analysis of three dimensional frames having offset prismatic members are investigated. The sources of offset considered are the rigid gusset plate effects and misalignment of members from specified joint positions. The secondary effects due to axial forces are also considered in the analysis. The displacement method of structural analysis is used with an iterative procedure to take into account the secondary effects. The complete stiffness matrix has been derived. The computer program developed, based on this analysis, is also explained. From the example of steel frame folded plate it is seen that the difference in maximum axial forces and bending moments due to the offset members are about 20%. It appears that the method, developed herein, for analysing space frames having offset members, offers a very direct and versatile approach to the problem of analyzing structures having misaligned members. (Author)

A81-18240 **The structural feasibility of a gravity stabilized antenna.** T. Yasaka (Nippon Telegraph and Telephone Public Corp., Yokosuka Electrical Communication Laboratory, Yokosuka, Kanagawa, Japan). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-28*. 12 p. 6 refs.

A very large earth oriented antenna structure which is stabilized by the gravity gradient force is analyzed and its feasibility is discussed. Stresses caused by gravity forces are analytically obtained by assuming that the antenna reflector is a spherical membrane. It is shown that a compression membered flexible reflector maintains its contour by adjusting the length of tethers which connect the reflector and the spacecraft main body. (Author)

A81-18241 **The thermal deflections of some large space structures.** C. Arduini (Roma, Università, Rome, Italy). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-29*. 25 p. 6 refs.

Indices of possible maximum static deflections under conventional thermal gradient in beam, plate, shell, membrane, and stinger structure are proposed. These indices are compared with the required surface accuracies for concepts such as maypoles, wrap ribs, and other antennas and platforms. The results indicate three structure categories: (1) double curvature shell-like configurations which limit thermal deflection by compression and tension along the parallels, (2) membrane and stringer types whose thermal variations produce local elongations only, and (3) beam and plate structures whose thermal bending makes it difficult to maintain surface stability. A.T.

A81-18242 **Method of packaging and deployment of large membranes in space.** K. Miura (Tokyo, University, Tokyo, Japan). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-31*. 11 p.

The purpose of this paper is to present a new concept of packaging and deployment of large membranes in space. The problem of biaxially folding of a plane is transferred to the elastic problem of a biaxially compressed infinite plate. After solving the problem, the plate thickness is reduced infinitesimally small, and thus the result represents the isometric transfer of an infinite plane subject to biaxial shortening. As a result, the concave polyhedral surface is discovered, which is composed of a repetition of a fundamental region, which is further composed of four congruent parallelograms. It is shown that the packaging and deployment by this surface geometry satisfies various requirements as to operations in space. (Author)

A81-18243 **Elastic waves propagation in the large periodic structures.** A. Agneni, F. Graziani, and S. Sgubini (Roma, Università, Rome, Italy). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-32*. 19 p. 12 refs.

Many continuum models for large repetitive lattice structures subjected to static and dynamic loadings have been developed in the literature. However the approximation of the lattice grids by homogeneous continuum models hides some typical properties of the periodic structures such as their filtering behavior associated with the wave propagation phenomena. This paper examines these phenomena using the Floquet theory and evaluates the dispersions relations both for discrete and continuous models. An example, derived from a very crude model of GSSPS shows the interaction between the bending vibrations of the solar arrays and the compressional waves of the central waveguide. (Author)

A81-18350 **Three-axis attitude dynamics during asymmetric deployment of flexible appendages.** K. W. Lips and V. J. Modi (British Columbia, University, Vancouver, Canada). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-E-227*. 18 p. 13 refs. Natural Sciences and Engineering Research Council of Canada Grant No. A-2181.

A general formulation is applied to the study of three-axis attitude response for a class of asymmetric spacecraft. The formulation allows for flexible beam-type appendages which are either fixed or deploying. In addition to flexibility, the effect of initial conditions, deployment rate and shift in the center of mass are also examined. Overall asymmetry is found to be a much more critical influence in the presence of flexibility. (Author)

A81-18353 * **On the dynamics of large orbiting flexible beams and platforms oriented along the local horizontal.** P. M. Bainum and V. K. Kumar (Howard University, Washington, D.C.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-E-230*. 21 p. 10 refs. Grant No. NsG-1414.

The dynamics and stability of large orbiting flexible beams and platforms oriented along the local horizontal are treated both analytically and numerically. It is assumed that such structures could be gravitationally stabilized by attaching a rigid lightweight dumbbell at the center of mass by a spring loaded hinge which also could provide viscous damping. For the beam it is seen that the small amplitude inplane pitch motion, dumbbell librational motion, and the anti-symmetric elastic modes are all coupled. The three dimensional equations of motion for a circular flat plate in orbit with a two-degree-of-freedom gimballed dumbbell are also developed and show that only those elastic modes described by a single nodal diameter line are influenced by the dumbbell motion. Stability criteria are developed for both examples and a parametric study of the least damped mode characteristics together with numerically simulated transient responses are carried out. (Author)

A81-20445 **Inherent damping, solvability conditions, and solutions for structural vibration control.** C. S. Greene (Honeywell Systems and Research Center, Minneapolis, Minn.) and G. Stein (Honeywell Systems and Research Center, Minneapolis, Minn.; MIT, Cambridge, Mass.). In: Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla.,

December 12-14, 1979, Proceedings. Volume 1.
Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 230-232. 14 refs.

This paper examines the significance of damping and finite modeling assumptions in the solution of vibration control problems. It shows that practical solutions are impossible unless sufficiently large inherent damping is assumed. Explicit formulas are developed for the required damping characteristics. (Author)

A81-29438 * # **Static and dynamic characteristics of large deployable space reflectors.** M. El-Raheb and P. Wagner (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 77-84. Contract No. NAS7-100. (AIAA 81-0503)

A linear numerical model of the structural characteristics of deployable reflectors was developed. Due to cyclic symmetry of the reflector structure about its axis, only one of many segments is modeled using finite elements. The succeeding segments satisfy continuity of displacement and slope at the interface between consecutive segments. This process leads to (N/2+1) static or dynamic problems of smaller order and bandwidth where N is the number of segments. The solution of each reduced problem leads to motions having a distinct circumferential wave number. The dynamic coupling to the feed support structure is studied adopting modal synthesis. (Author)

A81-29481 * # **Vibration of prestressed periodic lattice structures.** M. S. Anderson (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 501-506. 7 refs. (AIAA 81-0620)

Equations are developed for vibration of general lattice structures that have repetitive geometry. The method of solution is an extension of a previous paper for buckling of similar structures. The theory is based on representing each member of the structure with the exact dynamic stiffness matrix and taking advantage of the repetitive geometry to obtain an eigenvalue problem involving the degrees-of-freedom at a single node in the lattice. Results are given for shell-and beam-like lattice structures and for rings stiffened with tension cables and a central mast. The variation of frequency with external loading and the effect of local member vibration on overall modes is shown. (Author)

N81-19170*# Boeing Aerospace Co., Seattle, Wash.
INTEGRATED ANALYSIS CAPABILITY PILOT COMPUTER PROGRAM
R. G. Vos *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 73-86

Avail: NTIS HC A19/MF A01 CSCL 22B

An integrated analysis capability (IAC) computer software package was developed for the design analysis and performance evaluation of large space systems. The IAC aids the user in coupling the required technical disciplines (initially structures, thermal and controls), providing analysis solution paths which reveal critical interactive effects in order to study loads, stability and mission performance. Existing technical software modules, having a wide existing user community, are combined with the interface software to bridge between the different technologies and mathematical modeling techniques. The package is supported by executive, data management and interactive graphics software, with primary development within the superminicomputer environment. R.C.T.

N81-19188*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANALYTICAL PERFORMANCE PREDICTION FOR LARGE ANTENNAS
M. El-Raheb *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb 1981 p 325-338 ref

Avail: NTIS HC A19/MF A01 CSCL 22B

A linear mathematical modeling of the static and dynamic characteristics of a deployable offset wrap rib antenna was attempted using small motions in an effort to simulate the surface distortion resulting from thermal loading and transient oscillations from control. Both cyclic symmetry and model synthesis were used for parametric analysis. Although the ribs can be modeled as slender beams varying cross sections and equivalent linear material properties, the mesh poses a problem since its equivalent stress strain relations are highly nonlinear and sensitive to the biaxial prestressed state. Consequently, the macroscopic material properties were measured experimentally in the neighborhood of the design prestress. An equivalent tangent modulus technique was then adopted about this equilibrium state and assumed to be valid within a small range of incremental stresses. A.R.H.

N81-21108*# Vought Corp., Dallas, Tex.
STUDY OF THERMAL MANAGEMENT FOR SPACE PLATFORM APPLICATIONS
John A. Oren Dec. 1980 184 p refs Prepared in cooperation with Hughes Aircraft Co., Los Angeles, TRW Systems, Redondo Beach, Calif., Hamilton Standard, Hartford, Conn., General Dynamics/Astronautics, San Diego, Calif., and Lockheed Missiles and Space Co., Sunnyvale, Calif.
(Contract NAS3-22270)
(NASA-CR-165238; Rept-2-53020/OR-52578) Avail: NTIS HC A09/MF A01 CSCL 22B

Techniques for the management of the thermal energy of large space platforms using many hundreds of kilowatts over a 10 year life span were evaluated. Concepts for heat rejection, heat transport within the vehicle, and interfacing were analyzed and compared. The heat rejection systems were parametrically weight optimized over conditions for heat pipe and pumped fluid approaches. Two approaches to achieve reliability were compared for: performance, weight, volume, projected area, reliability, cost, and operational characteristics. Technology needs are assessed and technology advancement recommendations are made. E.A.K.

03
STRUCTURAL CONCEPTS

Includes erectable structures (joints, struts, and columns), deployable platforms and booms, solar sail, deployable reflectors, space fabrication techniques and protrusion processing.

A81-13361 # **Pressurized antennas for space radars.** M. Thomas and G. J. Friese (L'Garde, Inc., Newport Beach, Calif.). In: Sensor Systems for the 80's Conference, Colorado Springs, Colo., December 2-4, 1980, Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 65-71. 14 refs. Research supported by the L'Garde, Inc. and Thiokol AstroMet. (AIAA 80-1928)

The low weight and packaged volume of inflatables relative to mechanical systems has long been known. A 700-meter diameter inflated reflector could be carried in a single shuttle payload. Surface tolerances were demonstrated resulting in acceptable gains for microwave wavelengths greater than 1 cm. The total system weight including replacement gas is comparable to or lower than mechanical systems for antenna diameters greater than 10-20 meters. The meteoroid problem is much less than originally anticipated because large antennas require only low inflation pressures. Mechanisms for antenna thermal control include optimized internal radiative exchange and the use of the pressurant as in a heat pipe. (Author)

A81-20763 # **Space Platform Science/Application requirements.** S. T. Wu (Alabama, University, Huntsville, Ala.), W. W. L. Taylor (TRW, Inc., Redondo Beach, Calif.), D. Torr (Utah State University of Agriculture and Applied Science, Logan, Utah), and A. B. C. Walker (Stanford University, Stanford, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0340.* 17 p.

A preliminary fiscal analysis indicates that the Science and Application Space Platform (SASP) may be the most cost-effective approach to carrying out scientific investigations which require observing programs of several weeks to several years in space. Typical requirements for such a vehicle include an orbit with an altitude of 300-500 km and a 70-degree inclination; platform rate stabilities ranging from .002 deg/sec to .01 deg/sec; celestial and terrestrial orientation; and multiple channels with various data rates. Although power and resupply requirements vary widely, it is generally agreed that the SASP should be able to accept instruments with a Spacelab interface. Among the disciplines interested in SASP are high-energy astrophysics, astronomy, lunar and planetary sciences, solar physics, space plasma physics, and atmospheric sciences. R.S.

A81-20764 # **Concepts for science and applications space platforms.** F. C. Runge (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0342.* 11 p.

The multi-payload, free flying platform concept is designed to fulfill varied requirements of low earth orbit payloads plus platform interfaces with Power System, Orbiter, and Ground Operations. The configuration is modularized to provide utilization options such as (1) early, low-investment demonstration, (2) conservative escalation of capability, and (3) flexibility for multi-discipline or dedicated missions. Structural design for ridigity and compactibility are features along with optimized subsystem function allocation among the several system elements involved. Progression of payload accommodations and benefits of platform flight are presented. (Author)

A81-20765 # **Payload accommodations on science and applications space platforms.** R. V. Hauser (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0343.* 6 p.

Platform provides limited-duration Spacelab payloads an opportunity for extended flight, and for other payload classes it offers a lower-cost alternative to dedicated spacecraft. Services provided by the Platform to payloads - power, heat rejection, data transmission and storage, command, and pointing - are identified. For each service the Platform/payload interface is defined and a description of capabilities is presented. The dynamic environment of payloads on a platform are defined as are example accommodations for candidate experiments. (Author)

A81-22753 * # **Neutral buoyancy test results of a deployable space beam.** J. W. Stokes, E. E. Engler (NASA, Marshall Space Flight Center, Huntsville, Ala.), and W. E. Agan (Vought Corp., Dallas, Tex.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0437.* 5 p.

Large erectable and deployable space structures have been studied extensively in the past few years with a view toward usage in the near future for space platforms. The paper covers in particular the operational testing of a double-cell, double-folding cubic aluminum module at the Marshall Space Flight Center Neutral Buoyancy Simulator. Joining methods, deployment kinematics, configurations and operation time lines were analyzed using the Shuttle Remote Manipulator System (RMS) and EVA crewmen. Results of the test were considered successful, with crew tasks accomplished and the structural design adequate for flight design. N.D.

A81-22759 # **Systematic design of deployable space structures.** H. W. Stoll (Wisconsin, University, Platteville, Wis.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0444.* 10 p. 8 refs.

A systematic approach to deployable truss type space structure design is described. The approach is based on a morphological model in which the deployable structure is composed of a series of mechanical linkages. Each linkage undergoes constrained motion during deployment and upon full deployment, is 'hardened' to form one structural cell or unit in the deployed structure. The model consists of several fundamental elements which can be combined in a variety of ways to form a large number of different designs. These designs and their realization in terms of deployability, compactability, and structural acceptability are discussed. A deployable space structure classification scheme based on this model is also proposed. (Author)

A81-22760 * # **Progress in composite structure and space construction systems technology.** J. B. Bodle (General Dynamics Corp., Convair Div., San Diego, Calif.) and L. M. Jenkins (NASA, Johnson Space Center, Spacecraft Design Div., Houston, Tex.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0445.* 8 p. 6 refs.

The development of deployable and fabricated composite trusses for large space structures by NASA and private industry is reviewed. Composite materials technology is discussed with a view toward fabrication processes and the characteristics of finished truss beams. Advances in roll-forming open section caps from graphite-composite strip material and new ultrasonic welding techniques are outlined. Vacuum- and gravity-effect test results show that the ultrasonic welding of graphite-thermoplastic materials in space is feasible. The structural characteristics of a prototype truss segment are presented. A new deployable graphite-composite truss with high packaging density for broad application to large space platforms is described. L.S.

A81-24921 **Stability of beamlike lattice trusses.** A. K. Noor and L. S. Weisstein (George Washington University, Hampton, Va.). *Computer Methods in Applied Mechanics and Engineering*, vol. 25, Feb. 1981, p. 179-193. 14 refs.

A simple procedure is presented for predicting the buckling loads associated with general instability of large repetitive beam-like trusses. The procedure is based on replacing the original lattice structure by an equivalent continuum beam model and obtaining analytic solutions for the beam model. The continuum beam model accounts for warping and shear deformation in the plane of the cross section and is characterized by its strain energy and potential energy due to initial stresses from which the governing differential equations are derived. The high accuracy of the buckling predictions of the proposed continuum beam is demonstrated by means of numerical examples. (Author)

A81-29140 # **An evaluation of large space platforms.** D. Tong (Canadian Astronautics, Ltd., Ottawa, Canada). *(Canadian Aeronautics and Space Institute, Canadian Conference on Astronautics, 1st, Ottawa, Canada, Oct. 20-22, 1980.) Canadian Aeronautics and Space Journal*, vol. 26, 4th Quarter, 1980, p. 279-287. 6 refs. Research supported by the Department of Communications.

A progress report is presented on the conceptual development of large space platform orbiting systems whose construction is made feasible by the NASA Space Shuttle and similar hybrid booster vehicles. Because such multipurpose platforms would be able to replace individual satellites in the performance of communications functions, not merely technological and economic but legal and regulatory consequences of such systems must be considered. It is concluded that the implementation of large space platforms will be slower and more technologically modest than envisioned at first, and that institutional arrangements will strongly influence the date of their introduction. The interests of Canadian users and regulatory authorities are stressed throughout the study. O.C.

N81-11414*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RECENT ADVANCES IN STRUCTURAL TECHNOLOGY FOR LARGE DEPLOYABLE AND ERECTABLE SPACECRAFT

Harold G. Bush and Walter L. Heard, Jr. Oct. 1980 23 p refs Presented at the 31st Congr. of the Intern. Astron. Federation, Tokyo, 21-27 Sep. 1980
(NASA-TM-81905; IAF-Paper-80-A-27) Avail: NTIS HC A02/MF A01 CSCL 20K

Ultra-low mass deployable and erectable truss structure designs for spacecraft are identified using computerized structural sizing techniques. Extremely slender strut proportions are shown to characterize minimum mass spacecraft which are designed for shuttle transport to orbit. Discrete element effects using a recently developed buckling theory for periodic lattice type structures are presented. An analysis of fabrication imperfection effects on the surface accuracy of four different antenna reflector structures is summarized. The tetrahedral truss has the greatest potential of the structures examined for application to accurate or large reflectors. A deployable module which can be efficiently transported is identified and shown to have significant potential for application to future antenna requirements. Investigations of erectable structure assembly are reviewed. S.F.

N81-12008*# Wisconsin Univ., Platteville.

DEPLOYABLE STRUCTURE DESIGN FOR THE SCIENCE AND APPLICATIONS SPACE PLATFORM

Henry W. Stoll *In* Alabama Univ. Res. Rept.: The 1980 NASA/ASEE Summer Fac. Fellowship Program Oct. 1980 30 p refs
Avail: NTIS HC A99/MF A01 CSCL 22B

Basic concepts regarding deployable structures design, including systematic design/classification schemes and a deployability criterion, were proposed for use in synthesis, analysis and evaluation of alternative deployable structure designs. Using design guidelines based on SASP requirements and the basic concepts developed, a variety of designs were synthesized, and these along with previously proposed designs were analyzed and evaluated. Recommendations and conclusions regarding optimal deployable structure design were made. R.C.T.

N81-12155*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A TECHNOLOGY DEVELOPMENT PROGRAM FOR LARGE SPACE ANTENNAS

R. A. Russell, T. G. Campbell, and R. E. Freeland (JPL) Sep. 1980 45 p refs Presented at the 31st Intern. Astronautical Congr. of the Intern. Astronautical Federation, Tokyo, 21-28 Sep. 1980
(NASA-TM-81902; IAF-80-A-33) Avail: NTIS HC A03/MF A01 CSCL 22B

The design and application of the offset wrap rib and the maypole (hoop/column) antenna configurations are described. The NASA mission model that generically categorizes the classes of user requirements, as well as the methods used to determine critical technologies and requirements are discussed. Performance estimates for the mesh deployable antenna selected for development are presented. R.C.T.

N81-12445*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DEPLOYABLE AND ERECTABLE CONCEPTS FOR LARGE SPACECRAFT

H. G. Bush, W. L. Heard, Jr., J. E. Walz, and J. J. Rehder Oct. 1980 24 p refs Presented at the 39th Ann. Conf. of the Soc. of Allied Weight Engr., Inc., St. Louis, 12-14 May 1980
(NASA-TM-81904) Avail: NTIS HC A02/MF A01 CSCL 20K

Computerized structural sizing techniques were used to determine structural proportions of minimum mass tetrahedral truss platforms designed for low Earth and geosynchronous orbit. Optimum (minimum mass) deployable and erectable, hexagonal shaped spacecraft are sized to satisfy multiple design requirements and constraints. Strut dimensions characterizing minimum mass designs are found to be significantly more slender than those conventionally used for structural applications. Comparison studies show that mass characteristics of deployable and erectable platforms are approximately equal and that the shuttle flights required by deployable trusses become excessive above certain critical stiffness values. Recent investigations of erectable strut assembly are reviewed. Initial erectable structure assembly experiments show that a pair of astronauts can achieve EVA assembly times of 2-5 min/strut and studies indicate that an automated assembler can achieve times of less than 1 min/strut for around the clock operation. A.R.H.

N81-15366*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

DEVELOPMENT OF ASSEMBLY AND JOINT CONCEPTS FOR ERECTABLE SPACE STRUCTURES Final Report

G. G. Jacquemin, R. M. Bluck, G. H. Grotbeck, and R. R. Johnson Washington Dec. 1980 204 p refs
(Contract NAS1-15240)
(NASA-CR-3131) Avail: NTIS HC A10/MF A01 CSCL 22B

The technology associated with the on-orbit assembly of tetrahedral truss platforms erected of graphite epoxy tapered columns is examined. Associated with the assembly process is the design and fabrication of nine member node joints. Two such joints demonstrating somewhat different technology were designed and fabricated. Two methods of automatic assembly using the node designs were investigated, and the time of assembly of tetrahedral truss structures up to 1 square km in size was estimated. The effect of column and node joint packaging on the Space Shuttle cargo bay is examined. A brief discussion is included of operating cost considerations and the selection of energy sources. Consideration was given to the design assembly machines from 5 m to 20 m. The smaller machines, mounted on the Space Shuttle, are deployable and restowable. They provide a means of demonstrating the capabilities of the concept and of erecting small specialized platforms on relatively short notice. Author

N81-16380# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

REQUIREMENTS, DESIGN AND DEVELOPMENT OF LARGE SPACE ANTENNA STRUCTURES

May 1980 48 p refs Presented at the 49th Struct. and Mater. Panel Meeting, Porz-Wahn, West Germany, 7-12 Oct. 1979
(AGARD-R-678; ISBN-92-835-1358-4) Avail: NTIS HC A03/MF A01

The structural and materials requirements for space antennas are reviewed. The constraints imposed by the particular application and the space environment are addressed. In addition, structural design problems of large space structures and space telescopes are considered.

N81-16381# Communications Research Centre, Ottawa (Ontario). Dept. of Communications.
STRUCTURAL REQUIREMENTS AND CONSTRAINTS OF HIGH GAIN SATELLITE ANTENNAS FOR 30/20 GHz COMMUNICATIONS
Shabeer Ahmed *In* AGARD Requirements, Design and Develop. of Large Space Antenna Struct. May 1980 5 p refs

Avail: NTIS HC A03/MF A01

The types of satellite antennas, the mission constraints and environments for which they must be designed and the demands placed on the materials and structures of a reflector antenna to satisfy mission requirements are briefly outlined. The advantages and disadvantages of lens and phased array antennas are covered. The dimensional accuracy requirement of reflector antennas for 30/20 GHz communications is extremely stringent. The factors that contribute to dimensional inaccuracies are the structural design process, the physical properties of the constituent materials and the fabrication process that is utilized. Other antenna structural requirements include: low mass, to obtain the most payload in orbit; high strength, to withstand both launch loads and ground handling; and high stiffness, to withstand launch loads and to minimize interactions with the satellite control system. The antenna design must be capable of being verified in the 1 g environment on the ground. It must be capable of maintaining its designed geometric configuration in the space thermal environment. To meet this last requirement, an important design factor is the choice of materials which have low coefficients of thermal expansion and high thermal conductivity. Additional thermal protection is obtained from multilayer insulation blankets made of metallized plastic. Suggestions for structures and materials development are given. M.G.

N81-16382*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA TECHNOLOGY FOR LARGE SPACE ANTENNAS
Richard A. Russell, Thomas G. Campbell, and Robert E. Freeland (JPL) *In* AGARD Requirements, Design and Develop. of Large Space Antenna Struct. May 1980 2 p refs

Avail: NTIS HC A03/MF A01 CSCL 09C

Some leading concepts for deployable antennas are described and an assessment of the state of the art in deployable antennas is presented. The advanced sunflower precision antenna, the radial rib antenna and the maypole (hoop/column) antenna, the wrap rib antenna and the parabolic erectable truss antenna are covered. In addition, a discussion on the technology development program for two deployable antenna concepts that are responsive to the antenna mission requirements as defined in the NASA mission model is presented. M.G.

N81-16383# British Aerospace Dynamics Group, Stevenage (England).
TYPICAL EXAMPLES OF EUROPEAN TECHNOLOGY FOR HIGH STABILITY SPACE STRUCTURES
J. F. Clemmet *In* AGARD Requirements, Design and Develop. of Large Space Antenna Struct. May 1980 10 p

Avail: NTIS HC A03/MF A01

Two contrasting, primary areas of application of highly underformable space structures are identified to illustrate the state of the art in the European space industry. The technologies associated with the structures of high gain antennas and space telescopes are illustrated by selected examples. The philosophies adopted in translating the electrical or optical requirements initially into mechanical and thermal designs, and subsequently into hardware, are presented. Attention is given to deformations induced by launch and on station environments, to methods of controlling local environments and to demands from terrestrial assembly and integration. In addition to existing designs and hardware, current trends and developments are identified. Author

N81-17573*# Astro Research Corp., Carpinteria, Calif.
EFFICIENT STRUCTURES FOR GEOSYNCHRONOUS SPACECRAFT SOLAR ARRAYS
John M. Hedgepeth *In* NASA. Lewis Research Center Space Photovoltaic Res. and Technol. 1980 p 363-377 refs

(Contract NAS7-100)
Avail: NTIS HC A17/MF A01 CSCL 10A

Structural concepts for deploying and supporting lightweight solar array blankets for geosynchronous electrical power are evaluated. First, the requirements for more mass efficient solar arrays is established by describing future needs. Then analytical results are set forth which show that not only must lighter weight blankets be developed but also the supporting structure must be improved proportionately. The SEPS configuration is taken to be the state of the art point of departure for improved structural concepts. Several directions for improvement are indicated. J.M.S.

N81-18239# Rockwell International Corp., Canoga Park, Calif. Energy Systems Group.
COAL HYDROGASIFICATION PROCESS DEVELOPMENT. VOLUME 2: PEAT STUDIES Annual Technical Progress Report
K. M. Sprouse and J. K. Rosemary 20 Oct. 1980 151 p refs
(Contract DE-AC01-78ET-10328)
(FE-3125-24-Vol-2; ATPR-2-GFY-80) Avail: NTIS HC A08/MF A01

The effects of peat hydrogasification in an entrained flow reactor are discussed three phases: peat dense-phase feed system flow studies; hydrogasification entrained flow reactor testing; and preliminary peat process economic evaluations. The peat dense-phase feeding studies included low pressure (below 150 psig) testing at nominal solid peat flow rates of 1 ton/hr and analytical modeling efforts. The hydrogasification reactor testing was performed at peat flow rates of over 1000 lb/hr and reactor temperatures to 1900(0) F in hydrogen atmospheres from 500 to 1000 psig. A simple analytical kinetic model was developed to predict total carbon conversion as a function of reactor operating variables. DOE

N81-18244# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
LA RECHERCHE AEROSPATIALE, BIMONTHLY BULLETIN NO. 1980-2, MARCH - APRIL 1980
Claude Sevestre, ed. ESA 1980 79 p refs Transl. into ENGLISH of La Rech. Aerospatiale, Bull. Bimestriel (Paris), no. 1980-2, Mar. - Apr. 1980 p 77-145
(ESA-TT-652) Avail: NTIS HC A05/MF A01

Topics include turbulence formation, flow separation over swept wings, a closed-cycle helium turbine for solar power applications, elliptical flow computation, characterization of aircraft radar echoes, and a dynamic computer memory allocation system.

8410# Army Natick Labs., Mass.
VELOPMENT OF AN APPARATUS FOR BIAXIAL AND SHEAR STRESS-STRAIN TESTING OF FABRICS AND FILMS Final Report, Oct. 1975 - Sep. 1979
Constantin J. Monego and Malcolm N. Pilsworth, Jr. Oct. 1980 48 p refs
(AD-A094270; NATICK/TR-80/028) Avail: NTIS HC A03/MF A01 CSCL 11/5

This report describes the design, construction and evaluation of an apparatus for the measurement of the behavior of fabrics under biaxial tensile and shear forces. The instrument was evaluated by the testing of fabrics ranging in weight from 34 g/m to 48[illegible]g/m, corresponding to material applications ranging from lightweight parachute fabrics to heavyweight ballistic fabrics. The testwork demonstrates that the instrument, within the limitations of the testing techniques developed to date, can be used to provide the information necessary for the design of structural fabrics, the drafting of improved procurement specifications for fabrics and qualification of new fabrics for military applications. Technical problems and limitations of the instrument and of the testing techniques which require further study are discussed. GRA

N81-19179*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

ADVANCED SCIENCE AND APPLICATIONS SPACE PLATFORM

Jack White and Fritz Runge *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 133-148

Avail: NTIS HC A19/MF A01 CSCL 22B

Requirements for and descriptions of the mission equipment, subsystems, configuration, utilities, and interfaces for an Advanced Science and Applications Space Platform (ASASP) are developed using large space structure technology. Structural requirements and attitude control system concepts are emphasized. To support the development of ASASP requirements, a mission was described that would satisfy the requirements of a representative set of payloads requiring large separation distances selected from the Science and Applications Space Platform data base. Platform subsystems are defined which support the payload requirements and a physical platform concept is developed. Structural system requirements which include utilities accommodation, interface requirements, and platform strength and stiffness requirements are developed. An attitude control system concept is also described. The resultant ASASP is analyzed and technological developments deemed necessary in the area of large space systems are recommended. M.G.

N81-19183*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ELECTROSTATIC MEMBRANE ANTENNA CONCEPT STUDIES

J. W. Goslee *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 259-270

Avail: NTIS HC A19/MF A01 CSCL 22B

The development of an electrostatic membrane antenna for large space structure applications is discussed. Problems encountered in fabricating 4.88 m (16 foot) diameter thin film membranes are addressed. The development of a test fixture for evaluating the membranes and the comparison of surface measurement systems are also discussed. M.G.

N81-19187*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

OFFSET WRAP RIB ANTENNA CONCEPT DEVELOPMENT

A. A. Woods, Jr. *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 295-324 ref

Avail: NTIS HC A19/MF A01 CSCL 22B

A program to demonstrate large diameter offset reflector technology readiness through the development of ground testable, flight representative full size hardware also aims to provide a basis of data to allow confirmation of cost, performance, and size growth projections for the offset wrap rib antenna design. An overview of the antenna system is presented and the operational deployment sequence examined. The ability to manufacture multiple segment ribs is assured and tooling for rib manufacture was redesigned to reduce cost. The selected mast design permits adequate stiffness and minimum stowed volume. Reflector and mast concerns and the program plan are summarized. A.R.H.

N81-19191*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HOOP/COLUMN ANTENNA TECHNOLOGY DEVELOPMENT SUMMARY

Thomas G. Campbell *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 357-364

Avail: NTIS HC A19/MF A01 CSCL 22B

The Langley Research program for development of hoop/column antenna technology was redirected and includes the fabrication and test of models such as the 4 gore segment of a 50 meter antenna and the 15 meter diameter fully deployable antenna. Significant results were obtained in the point design that includes a quad aperture reflector system for multiple beam applications. A.R.H.

N81-19192*# Harris Corp., Melbourne, Fla. Government Systems Group.

DEVELOPMENT OF THE MAYPOLE (HOOP/COLUMN) DEPLOYABLE REFLECTOR CONCEPT FOR LARGE SPACE SYSTEMS APPLICATION

D. C. Montgomery *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 365-406

(Contract NAS1-15763)

Avail: NTIS HC A19/MF A01 CSCL 22B

A review of the NASA supplied mission scenarios for the communications, radiometry and radio astronomy missions. Led to specific hoop/column antenna configurations for each mission. The mission configurations were then evaluated to identify specific technology items requiring further development. The compilation of these technology drivers resulted in a specification of an artificial or point design, the design element around which all design and performance estimates for the rest of the program were made. Mechanisms for deployment and stowing are examined including the cable driven mast and the latch pulley roller. Methods for determining the thermal expansion of candidate materials, the development of the cables, cords, and hinged joints, and surface adjustment are considered. A.R.H.

N81-19194*# General Electric Co., Philadelphia, Pa. Valley Forge Center.

OFFSET FED UTILIZATION OF FOUR QUADRANTS OF AN AXIALLY SYMMETRICAL ANTENNA STRUCTURE

P. Foldes *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 431-438

Avail: NTIS HC A19/MF A01 CSCL 22B

Theoretical calculations conducted for the use of the hoop column structure were in a quad antenna configuration. The coverage of the US 48 states by a C band Comsat system, which operates in the 3.7 - 4.2 GHz downlink and 5.925 - 6.425 GHz uplink frequency band is considered. This system provides most of its coverage toward major cities (10 or 18 spot beams) and the rest of its coverage on a contiguous basis for the remaining of the country. An alpha = .5 and .3 cell size (approximate component bandwidth) is assumed. Among the practically infinite possible beam topologies one plan for the area coverage and three plans for the spot beam coverage are analyzed. A.R.H.

N81-19197*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

OPTIMUM DAMPER LOCATIONS FOR A FREE-FREE BEAM

G. C. Horner *In its* The 1980 Large Space System Technol., Vol. 2 Feb. 1981 p 5-18

Avail: NTIS HC A09/MF A01 CSCL 22B

Algorithms to optimally locate and design dampers for large space structures were developed. The requirements for distributed sensing and actuation in control of structural systems were determined. Mathematical programming was used to solve for optimum damping rate and location. Actuator dynamics were considered to solve for optimum actuator mass. E.D.K.

N81-19199*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

BUCKLING AND VIBRATION OF PERIODIC LATTICE STRUCTURES

Melvin S. Anderson *In its* The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 35-44 ref

Avail: NTIS HC A09/MF A01 CSCL 22B

Lattice booms and platforms composed of flexible members or large diameter rings which may be stiffened by cables in order to support membrane-like antennas or reflector surfaces are the main components of some large space structures. The nature of these structures, repetitive geometry with few different members, makes possible relatively simple solutions for buckling and vibration of a certain class of these structures. Each member is represented by a stiffness matrix derived from the exact solution of the beam column equation. This transcendental matrix gives the current member stiffness at any end load or frequency. Using conventional finite element techniques, equilibrium equations can be written involving displacements and rotations of a typical node and its neighbors. The assumptions of a simple trigonometric mode shape is found to satisfy these equations exactly; thus the entire problem is governed by just one 6 x 6 matrix equation involving the amplitude of the displacement and rotation mode shapes. The boundary conditions implied by this solution are simple supported ends for the column type configurations. E.D.K.

N81-19200*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

STRUCTURAL SIZING CONSIDERATIONS FOR LARGE SPACE STRUCTURES

Walter L. Heard, Jr., Harold G. Bush, and Joseph E. Walz *In its* The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 45-58 refs

Avail: NTIS HC A09/MF A01 CSCL 22B

A number of missions for the space shuttle were proposed which involve placing large truss platforms on-orbit. These platforms range in size from tens of meters in span for reflector application to several thousand meters for solar power collector application. These proposed sizes and the operational requirements considered are unconventional in comparison to Earthbound structures and little information exists concerning efficient proportions of the structural elements forming the framework of the platforms. Such proportions are of major concern because they have a strong influence on the packaging efficiency and, thus, the transportation effectiveness of the shuttle. The present study is undertaken to: (1) identify efficient ranges of application of deployable and erectable platforms configured for shuttle transport to orbit, and (2) determine sensitivity to key parameters of minimum mass deployable and erectable platform designs.
E.D.K.

N81-19201*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DEPLOYMENT TESTS OF A 36-ELEMENT TETRAHEDRAL TRUSS MODULE

R. W. Herr and G. C. Horner *In its* The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 59-69

Avail: NTIS HC A09/MF A01 CSCL 22B

In the past, models of deployable structures were limited largely to small scale models which could be readily deployed by suspending the model on several soft shock cords. The scale of the deployable truss used in the present investigation precluded the use of this test technique as the gravity forces and moments are of the same order of magnitude as the deployment forces and moments. For these tests, the truss was deployed during free-fall in the LaRC 55' vacuum facility. Appreciably larger trusses could be deployed by lofting the packaged truss upward from the floor of the facility and allowing it to deploy during the upward as well as the downward portion of its trajectory, thus doubling the available test time. It must be realized, of course, that the mechanisms required to loft and decelerate such a large truss, would be much more complex than those required for a straight drop. E.D.K.

N81-19203*# Astro Research Corp., Carpinteria, Calif.

FREE-FLYING SOLAR REFLECTOR SPACECRAFT

John M. Hedgepeth *In* NASA. Langley Research Center The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 89-101 refs

Avail: NTIS HC A09/MF A01 CSCL 22B

Results of investigations of requirements and design concepts for large solar-reflecting spacecraft are given. The emphasis is on the one kilometer diameter self contained spacecraft that can be packaged and launched in the space shuttle. The configuration consists of a compression rim stabilized by stays coming from each end of the central compression hub. The stays are stowed on reels on the ends of the hub. The hub consists of two Astromasts which are deployed after launch. The reflector membrane is a two micron thick Kapton film with a vapor deposited aluminum coating. E.D.K.

N81-20482*# General Dynamics/Convair, San Diego, Calif. Advanced Space Programs Dept.

GRAPHITE COMPOSITE TRUSS WELDING AND CAP SECTION FORMING SUBSYSTEMS. VOLUME 1: EXECUTIVE SUMMARY Final Report

31 Oct. 1980 42 p

(Contract NAS8-15973)

(NASA-CR-160933; GDC-ASP-80-007-Vol-1) Avail: NTIS HC A03/MF A01 CSCL 20K

A rolltrusion process was developed for forming of a hybrid, single-ply woven graphite and glass fiber cloth, impregnated with a polysulfone resin and coated with TiO2 pigmented P-1700 resin into strips for the on-orbit fabrication of triangular truss segments. Ultrasonic welding in vacuum showed no identifiable effects on weld strength or resin flow characteristics. An existing bench model cap roll forming machine was modified and used to roll form caps for the prototype test truss and for column test specimens in order to test local buckling and torsional instability characteristics. A.R.H.

N81-20483*# General Dynamics/Convair, San Diego, Calif. Advanced Space Programs Dept.

GRAPHITE COMPOSITE TRUSS WELDING AND CAP SECTION FORMING SUBSYSTEMS. VOLUME 2: PROGRAM RESULTS Final Report

31 Oct. 1980 104 p refs

(Contract NAS8-15973)

(NASA-CR-160932; GDC-ASP-80-007-Vol-2) Avail: NTIS HC A06/MF A01 CSCL 20K

The technology required to develop a beam builder which automatically fabricates long, continuous, lightweight, triangular truss members in space from graphite/thermoplastics composite materials is described. Objectives are: (1) continue the development of forming and welding methods for graphite/thermoplastic (GR/TP) composite material; (2) continue GR/TP materials technology development; and (3) fabricate and structurally test a lightweight truss segment. S.F.

N81-21080*# Grumman Aerospace Corp., Bethpage, N.Y.

SPACE FABRICATION DEMONSTRATION SYSTEM Quarterly Progress Report, 27 Aug. - 15 Nov. 1977

15 Nov. 1977 194 p refs

(Contract NAS8-32742)

(NASA-CR-161693; NSS-SFDS-LR022; QPR-3) Avail: NTIS HC A09/MF A01 CSCL 22A

Progress on fabrication facility (beam builder) support structure control, clamp/weld block, and welding and truss cut off is discussed. The brace attachment design was changed and the design of the weld mechanism was modified which achieved the following system benefits: (1) simplified weld electrode life; (2) reduced weld power requirements; and (3) simplified brace attachment mechanisms. Static and fatigue characteristics of spot welded 2024T3 aluminum joints are evaluated. E.A.K.

N81-21081*# Grumman Aerospace Corp., Bethpage, N.Y.

SPACE FABRICATION DEMONSTRATION SYSTEM Quarterly Progress Report, 16 Nov. 1977 - 15 Feb. 1978

16 Feb. 1978 41 p refs
(Contract NAS8-32472)
(NASA-CR-161694; NSS-SFDS-LR028; QPR-4) Avail: NTIS HC A03/MF A01 CSCL 22A

Progress in the mechanical/structural assembly of the beam builder is reported. The following structures were investigated: cross brace magazine/dispenser subsystem; and rolling mill supply reel, guide, and drive. The fabrication facility design and a detail design of all major subsystem components are discussed. The number of spot welds per structural joint were reduced which enables the doubling of length of truss which can be produced within known electrode life limits.

E.A.K.

N81-21082*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE FABRICATION DEMONSTRATION SYSTEM Quarterly Progress Report, 16 Feb. - 15 May 1978
15 May 1978 127 p refs
(Contract NAS8-32472)
(NASA-CR-161695; NSS-SFDS-LR040; QPR-5) Avail: NTIS HC A07/MF A01 CSCL 22A

The completion of assembly of the beam builder and its first automatic production of truss is discussed. A four bay, hand assembled, roll formed members truss was built and tested to ultimate load. Detail design of the fabrication facility (beam builder) was completed and designs for subsystem debugging are discussed. Many one bay truss specimens were produced to demonstrate subsystem operation and to detect problem areas.

E.A.K.

N81-21083*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE FABRICATION DEMONSTRATION SYSTEM Quarterly Progress Report, 16 Sep. - 15 Dec. 1978
30 Dec. 1978 20 p refs
(Contract NAS8-32472)
(NASA-CR-161706; NSS-SFDS-LR069; QPR-6) Avail: NTIS HC A02/MF A01 CSCL 22A

The lower right aluminum beam cap roll forming mill was delivered and installed in the beam builder. The beam was brought to full operational status and beams of one to six bay lengths were produced to demonstrate full system capability. Although the cap flange waviness problem persists, work is progressing within cost and schedule.

A.R.H.

N81-21084*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE FABRICATION DEMONSTRATION SYSTEM Quarterly Progress Report, 17 May - 20 Aug. 1977
30 Aug. 1977 132 p refs
(Contract NAS8-32472)
(NASA-CR-161708; NSS-SFDS-LR013; QPR-2) Avail: NTIS HC A07/MF A01 CSCL 22A

Progress in the development of a beam builder to be deployed by space shuttle for assembly of large structures in space is reported. The thermal coating for the structural truss was selected and the detail truss design and analysis completed. Data acquired during verification of the design of the basic 'building block' truss are included as well as design layouts for various fabrication facility subsystems.

J.M.S.

N81-21085*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE FABRICATION DEMONSTRATION SYSTEM Quarterly Progress Report, 16 Sep. - 15 Dec. 1979
3 Jan. 1980 11 p refs
(Contract NAS8-32472)
(NASA-CR-161704; QPR-10) Avail: NTIS HC A02/MF A01 CSCL 22A

The development effort on the composite beam cap fabricator was completed within cost and close to abbreviated goals. The design and analysis of flight weight primary and secondary beam builder structures proceeded satisfactorily but remains curtailed until further funding is made available to complete the work. The induction fastening effort remains within cost and schedule constraints. Tests of the LARC prototype induction welder is continuing in an instrumented test stand comprised of a Dumore drill press (air over oil feed for variable applied loads) and a dynamometer to measure actual welding loads. Continued testing shows that the interface screening must be well impregnated with resin to ensure proper flow when bonding graphite-acrylic lap shear samples. Specimens prepared from 0.030 inch thick graphite-polyethersulfone are also available for future induction fastening evaluation.

A.R.H.

N81-21101*# Essex Corp., Huntsville, Ala.
STRUCTURAL ATTACHMENTS FOR LARGE SPACE STRUCTURES Final Report
Edwin C. Pruett, Thomas E. Loughead, and Kam B. Robertson, III 15 Oct. 1980 42 p
(Contract NAS8-33599)
(NASA-CR-161685; H-80-04) Avail: NTIS HC A03/MF A01 CSCL 22B

The feasibility of fabricating beams in space and using them as components of a large, crew assembled structure, was investigated. Two projects were undertaken: (1) design and development of a ground version of an automated beam builder capable of producing triangular cross section aluminum beams; and (2) design and fabrication of lap joints to connect the beams orthogonally and centroidal end caps to connect beams end to end at any desired angle. The first project produced a beam building machine which fabricates aluminum beams suitable for neutral buoyancy evaluation. The second project produced concepts for the lap joint and end cap. However, neither of these joint concepts was suitable for use by a pressure suited crew member in a zero gravity environment. It is concluded that before the beams can be evaluated the joint designs need to be completed and sufficient joints produced to allow assembly of a complex structure.

E.A.K.

04
CONTROL SYSTEMS

Includes new attitude and control techniques, improved surface accuracy measurement and control techniques.

A81-14994 * # **Figure control of flexible structures - Optical surfaces of thin deformable primary mirrors.** J. F. Creedon and A. J. Ostroff (NASA, Langley Research Center, Hampton, Va.). *Institute of Electrical and Electronics Engineers, Conference on Decision and Control, 19th, Albuquerque, N. Mex., Dec. 10-12, 1980, Paper.* 9 p. 7 refs.

Application of a modal control design technique to achieve discrete control of distributed parameter systems is considered. Results are presented for application of the design technique to achieve diffraction limited performance from the primary mirror of a space telescope and to provide flutter suppression for an aircraft wing. (Author)

A81-18348 **Spacecraft dynamics and control.** P. Y. Willems (Louvain, Université Catholique, Louvain-la-Neuve, Belgium). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-E224.* 14 p. 12 refs.

Problems relating to the dynamic behavior and control of large space structures are reviewed in this survey of literature on the topic. The existing various points of view are presented in a unified approach that defines the different hypotheses which are classically used in this field. A general description of the dynamics of deformable systems is employed to derive the various models appearing in the literature. T.M.

A81-18358 * **Stability and control of flexible satellites. II - Control.** T. C. Huang (Wisconsin, University, Madison, Wis.) and A. Das (General Electric Co., Space Div., Valley Forge, Pa.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-E-225.* 12 p. 7 refs. Contract No. NAS5-21798.

It is demonstrated that by monitoring the deformations of the flexible elements of a satellite, the effectiveness of the satellite control system can be increased considerably. A simple model of a flexible satellite was analyzed in the first part of this work. The same model is used here for digital computer simulations. (Author)

A81-18367 **Two-body control for rapid attitude maneuvers.** R. Quartararo (Rockwell International Corp., Satellite Systems Div., Seal Beach, Calif.). In: Guidance and control 1980; Proceedings of the Annual Rocky Mountain Conference, Keystone, Colo., February 17-21, 1980. San Diego, Calif., Univelt, Inc., 1980, p. 397-422. (AAS 80-023)

A concept is presented for rapidly changing the attitude of large space-based sensors. It is implemented by dividing a spacecraft into two bodies - a pointed body and a reaction body - which are connected by a gimbal drive mechanism. The drive unit applies torques to the pointed body in order to control its attitude, and the reaction body counter rotates in response to the control action. Performance is evaluated by using closed form analytical expressions to parametrically examine the motion of selected vehicle configurations. Results show that very big pointed bodies joined with smaller reaction bodies can be reoriented through large angles without excessive gimbal angle motion. (Author)

A81-18369 **Rotational maneuvers of large flexible spacecraft.** K. T. Alfriend (U.S. Navy, Naval Research Laboratory, Washington, D.C.) and R. W. Longman (Columbia University, New York, N.Y.). In: Guidance and control 1980; Proceedings of the Annual Rocky Mountain Conference, Keystone, Colo., February 17-21, 1980. San Diego, Calif., Univelt, Inc., 1980, p. 453-475. 14 refs. (AAS 80-025)

Consideration is given to the problem of controlling a large flexible spacecraft during a large-angle rotational maneuver. Optimal maneuvers of a flexible spacecraft about a principal axis are examined and an example of the problem is presented which results in an open-loop control law. The concept of degree of controllability is introduced and a simple method for calculating it is developed in order to aid system designers in determining actuator locations for the control of maneuvering flexible spacecraft. Methods for suppressing the effect of residual modes on control system behavior are then considered which take into consideration the balance between the deleterious effects of control spillover and of spillover suppression. A.L.W.

A81-18370 **Active control of flexible space structures.** S. M. Seltzer. In: Guidance and control 1980; Proceedings of the Annual Rocky Mountain Conference, Keystone, Colo., February 17-21, 1980. San Diego, Calif., Univelt, Inc., 1980, p. 477-489. 17 refs. Research supported by the Charles Stark Draper Laboratory, Inc. (AAS 80-026)

Consideration is given to the problem of actively pointing and controlling the attitude and shape of a flexible spacecraft in earth orbit. The modeling of the dynamics of the spacecraft to be controlled is examined, and various approaches to structural dynamic control are outlined in the areas of centralized and decentralized control. Problems and potential pitfalls associated with the design of structural control systems are then identified, with attention given to the specification of performance requirements, stability criteria, control robustness, dynamic modeling, input disturbances, the determination of effectors, actuators and sensors, computer requirements, reliability and system validation. A.L.W.

A81-18377 **Digital mechanization for structural control.** J. A. Breakwell, J. Chambers (Lockheed Missiles and Space Co., Inc., Palo Alto, Calif.), G. Hamma, and R. Stroud (Synergistic Technology, Inc., Cupertino, Calif.). In: Guidance and control 1980; Proceedings of the Annual Rocky Mountain Conference, Keystone, Colo., February 17-21, 1980. San Diego, Calif., Univelt, Inc., 1980, p. 679-705. 11 refs. (AAS 80-035)

Stability augmentation for flexible space structures using digital mechanizations is discussed with particular emphasis on current experimental work. Software/hardware aspects of both the control and identification problem are addressed from both historical and contemporary viewpoints. Representative hardware systems for ground testing are given and limitations imposed by antialiasing systems are reviewed. An example illustrating digital control of the first three antisymmetric modes of a flexible test structure is given to show feasibility. (Author)

A81-20427 **An aggregation method for active control of large space structures.** T. L. Johnson (MIT, Cambridge, Mass.) and J. G. Lin (Charles Stark Draper Laboratory, Inc., Cambridge, Mass.). In: Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla., December 12-14, 1979, Proceedings. Volume 1. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 1-3. 12 refs. DARPA-supported research; NSF Grant No. ENG-77-2844.

An approach to model reduction that does not involve the direct truncation of open-loop modal representations is discussed. Here, the open-loop modes are first aggregated on the basis of the influence of the actuators and sensors. Since with direct truncation noncritical natural modes are neglected, preliminary aggregation has the advantage that the coupling with the neglected portion becomes independent of feedback control gains and is thus much more readily predicted. A class of linear transformations from modal form to aggregate form, which is stable under increases of finite-element model order, is demonstrated. Alternative design models are then defined, and perturbation theory is applied to obtain explicit bounds on the coupling effects and, in particular, the limitations of pole shifting on the neglected portion by linear dynamic compensation. It is found that the aggregation method has the advantage over the usual modal truncation that the coupling coefficients, though not small, do not depend on the compensator parameters or feedback gains. C.R.

A81-20442 **Model error sensitivity suppression - Quasi-static optimal control for flexible structures.** J. R. Sesak (General Dynamics Corp., Convair Div., San Diego, Calif.) and P. W. Likins (Columbia University, New York, N.Y.). In: Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla., December 12-14, 1979, Proceedings. Volume 1. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 207-213. 29 refs.

Model Error Sensitivity Suppression (MESS) provides simultaneous solution for two control problems inherent to flexible spacecraft control: a dynamic problem-modal stabilization, and a static problem modal decoupling. The MESS algorithm is developed in simplified form to illustrate the decoupling properties of the algorithm. An example is presented that highlights an interesting property of the algorithm; namely, the determination of the directions of the column vectors of the optimal gain matrix, a priori, before solution of the Riccati equation. Similar results hold for dual estimator design. These static decoupling properties of the algorithm allow reduced-order estimating and decentralized control. (Author)

A81-20443 **Adaptive control for large space structures.** R. J. Benhabib, R. P. Iwens, and R. L. Jackson (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In: Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla., December 12-14, 1979, Proceedings. Volume 1. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 214-217. 16 refs.

Direct adaptive control is applied to the active vibration damping problem in large space structures (LSS). The method outlined exploits the dynamical properties of LSS in order to modify the established stable adaptive methods so that the closed-loop infinite dimensional system is boundary input, boundary output stable in the large. An example, the control of a flat plate, is used to demonstrate the performance of the design when modal frequencies and shapes are varied and when there is an actuator-sensor failure. (Author)

A81-20444 * **Computational aspects of the control of large flexible structures.** L. Meirovitch and H. Oz (Virginia Polytechnic Institute and State University, Blacksburg, Va.). In: Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla., December 12-14, 1979, Proceedings. Volume 1. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 220-229. 18 refs. Grant No. NCC1-4.

This paper advances a unified theory for the modal-space control method developed by these authors for the control of large flexible structures and places the theory on a more rigorous foundation. The unified approach permits the simultaneous treatment of a broad spectrum of interrelated problems. In particular, the theory is valid for both nongyroscopic and gyroscopic systems and for systems with ignorable coordinates resulting from rigid body motions. In addition, it permits a convenient way of studying the question of control spillover. The modal-space control method is different from any other modal control method in that it provides both internal (plant) and external (controller) decoupling. (Author)

A81-20604 **A survey of the large structures control problem.** R. Green and M. Rossi (Grumman Aerospace Corp., Research Dept., Bethpage, N.Y.). In: Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla., December 12-14, 1979, Proceedings. Volume 2. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979, p. 1002-1007. 18 refs.

It is noted that the control of a large structure is difficult because the dynamic model of such systems is a partial differential equation. Since the controller must be finite dimensional, the problem arises of how to develop a finite dimension controller for an infinite dimensional plant. The equation describing the motion of any large structure in a continuum is analyzed, and finite element models are discussed. Attention is also given to order reduction for large structures, and alternate procedures for deriving control systems, for example, direct output feedback, are discussed. The desirable properties that a large structure should have, including insensitivity to model parameters and stability over a wide range of structural motion, are enumerated. C.R.

A81-20590 * # **Generic model of a large flexible space structure for control concept evaluation.** H. B. Hablani and R. E. Skelton (Purdue University, West Lafayette, Ind.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0086.* 12 p. 7 refs. Contract No. JPL-955639.

The objective of the paper is to propose a generic model on the shape and attitude control of a representative space structure. Reduction of the finite element model is based on modal identities and modal cost analysis. The model may help to: (a) suggest improved methods for designing reduced order controllers for large elastic spacecraft, (b) enhance coherence between the frequency-response and time-response multivariable applications, (c) examine computational efficiency of the multivariable control algorithms, and (d) suggest other desirable theoretical and numerical research areas. (Author)

A81-22785 * # **An observer for a deployable antenna.** H. B. Waites (NASA, Marshall Space Flight Center, Huntsville, Ala.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0453.* 6 p. 7 refs.

An observer is derived for use on an Orbiter-Deployable Antenna configuration. The unique feature of this observer design for this flight experiment is that all the plant inputs are not required to be directly accessible for the observer to ferret out the system states. The observer uses state and rate of the state information to reconstruct the plant states. Results are presented which show how effectively this observer design works for this large space structure flight experiment. (Author)

A81-22786 * # **An asymptotically stable damping enhancement controller for large space structures.** S. M. Joshi (Vigyan Research Associates, Inc., Hampton, Va.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0455.* 9 p. 9 refs. Contract No. NAS1-16126.

A secondary controller which uses a number of Annular Momentum Control Devices (AMCD's) for enhancement of structural damping in large flexible space structures is investigated. The closed-loop secondary controller is shown to be equivalent to a certain closed-loop optimal linear regulator, and the necessary and sufficient conditions for asymptotic stability are obtained. Sufficient conditions for asymptotic stability are also obtained which are much less restrictive than those obtained in an earlier paper. Design of a robust stable primary controller is also discussed. (Author)

A81-26625 **Optimization of large structure sensor designs.** Y.-W. A. Wu (Martin Marietta Aerospace, Denver, Colo.). In: Asilomar Conference on Circuits, Systems, and Computers, 13th, Pacific Grove, Calif., November 5-7, 1979, Conference Record.

Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1980, p. 182-186. 20 refs.

The problems of optimal sensor location design solutions with or without location constraints, and suboptimal solutions with location constraints, are formulated. The solution of suboptimal problems is arrived at with a simple, computer-implemented formulation, and simulation studies made for the yaw attitude control of a representative large spacecraft are presented for demonstration of the method. O.C.

A81-26656 **Optimal actuator and sensor locations in oscillatory systems.** A. Arbel and N. K. Gupta (Systems Control, Inc., Palo Alto, Calif.). In: Asilomar Conference on Circuits, Systems, and Computers, 13th, Pacific Grove, Calif., November 5-7, 1979, Conference Record. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1980, p. 385-388. 5 refs.

The problem of actuator and sensor locations for oscillatory systems is considered. Using the controllability matrix, an actuator location is derived from the solution of the minimum energy control problem. In the case of the sensor location problem, the controllability matrix is replaced by the observability matrix. The form of the observability matrix as well as its steady-state value are similar to those of the controllability matrix. In many physical oscillatory systems, the optimal sensor locations are the same as the optimal actuator locations. L.S.

A81-28741 **Controllability measures and actuator placement in oscillatory systems.** A. Arbel (Advanced Information and Decisions Systems, Mountain View, Calif.). *International Journal of Control*, vol. 33, Mar. 1981, p. 565-574. 6 refs.

Oscillatory systems provide a good linear description of large flexible space structures. Considering the problem of controllability measures for these systems leads to a design approach for actuator placement in such systems. It is shown that the mathematical form associated with an oscillatory system lends itself to a complete modal analysis that can be written in closed form. This available modal structure and the controllability measures are combined to yield a design approach for optimal placement of actuators in oscillatory systems. (Author)

A81-29437 # **Attitude dynamics of a satellite during deployment of large plate-type structures.** A. E. Ibrahim and A. K. Misra (McGill University, Montreal, Canada). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 69-76. 12 refs. (AIAA 81-0502)

The paper analyzes the attitude dynamics of a spacecraft while deploying large plate-like structures. Equations governing the rotational dynamics of the system and the lateral vibrations of the panels are obtained using a Lagrangian formulation. Even the linearized equations are unusually lengthy and involve time varying coefficients. Hence, they are integrated numerically for given length histories. Two types of axial extension, uniform and exponential, are considered. The system parameters are varied for the two procedures and their influence on the attitude dynamics is noted. (Author)

A81-29492 # **On the placement of actuators in the control of distributed-parameter systems.** H. Baruh and L. Meirovitch (Virginia Polytechnic Institute and State University, Blacksburg, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 611-620. 17 refs. (AIAA 81-0638)

The problem of actuator location for the control of distributed-parameter systems is investigated. The control scheme is based on the concept of independent modal-space control and it uses input energy as a criterion for the placement of the actuators. To this end, an expression for the work done by the actuators on the distributed-parameter system is derived. Using that expression, it is shown that the amount of energy required to control the controlled modes by the modal-space control method is independent of the actuator location. It is also shown that, because the actuators are discrete elements, part of the energy imparted to the system does go into the uncontrolled modes. The portion of energy going into each of the uncontrolled modes can be monitored. As the number of controlled modes is increased, the energy going into uncontrolled modes decreases. Based on the above considerations, some guidelines for the location of the actuators in a distributed-parameter system are suggested. (Author)

N81-10099 Virginia Polytechnic Inst. and State Univ., Blacksburg.
OPTIMAL LARGE ANGLE SPACECRAFT ROTATIONAL MANEUVERS Ph.D. Thesis
James Daniel Turner 1980 209 p
Avail: Univ. Microfilms Order No. 8024020

Problems associated with optimal large angle spacecraft rotational maneuvers are discussed. Both rigid and flexible body dynamical models for these vehicles are considered. Three relaxation/analytic continuation methods are developed for iteratively solving the two point boundary value problem which results in the treatment of these problems. Boundary condition relaxation processes, differential relaxation processes, and hybrid relaxation processes are detailed. In the literature these relaxation processes are closely related to a number of methods for solving nonlinear equations, imbedding, and homotopy chain methods. Dissert. Abstr.

N81-11100 Columbia Univ., New York.
ASPECTS OF CONTROL OF LARGE FLEXIBLE SPACECRAFT Ph.D. Thesis
Chittur Natarajan Viswanathan 1980 249 p
Avail: Univ. Microfilms Order No. 8023561

A meaningful concept of the degree of controllability of a system is developed which takes into consideration all the pertinent factors such as controllability, total time of control, control effort, stability, and control objective which should have a bearing on the degree of controllability. An algorithm to generate an approximation to this degree of controllability was developed which satisfies the condition that the approximate measure goes to zero if and only if the system becomes uncontrollable. Using this concept it was possible to compare a set of potential control system designs for a given space structure, each using a different distribution of actuator locations, and to decide which design was best. Dissert. Abstr.

N81-11103# Toronto Univ., Downsview (Ontario).
ACTIVE CONTROL OF DYNAMICS TRANSFER FUNCTIONS FOR A FLEXIBLE SPACECRAFT
S. C. Garg Oct. 1979 74 p refs
(UTIAS-239; CN-ISSN-0082-5255) Avail: NTIS HC A04/MF A01

Flexible spacecraft consisting of a central rigid body and flexible appendages are examined. The dynamics of each appendage are discussed with emphasis on introducing transfer functions for point excitation in translation and rotation. The transfer matrix for the entire spacecraft is derived and details are given for pitch/twist attitude control of Hermes (CTS). The expressions are found useful in several respects, being devoid of modal truncation. A scheme is examined which modifies the spacecraft transfer function actively using acceleration feedback. Numerical results are obtained for Hermes, and then confirmed from an attitude control simulation incorporating control nonlinearities. Dynamics modification under ground control is also examined, including time delays, and an experiment of this type is proposed for Hermes. R.C.T.

N81-13082*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DECOUPLED CONTROL OF A LONG FLEXIBLE BEAM IN ORBIT
Harold A. Hamer and Katherine G. Johnson Dec. 1980 77 p refs
(NASA-TP-1740; L-13726) Avail: NTIS HC A05/MF A01 CSCL 22B

Control involved commanding changes in pitch attitude as well as nulling initial disturbances in the pitch and flexible modes. Control force requirements were analyzed. Also, the effects of parameter uncertainties on the decoupling process were analyzed and were found to be small. Two methods were investigated: the system was completely coupled and certain actuators were then eliminated, one by one, which resulted in some or all modes not fully controlled; specified modes of the system were excluded from the decoupling control law by employing fewer control actuators than modes in the model. In both methods, adjustments were made in the feedback gains to include the uncontrolled modes in the overall control of the system.
Author

N81-13992*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FINITE ELEMENT STRUCTURAL MODEL OF A LARGE, THIN, COMPLETELY FREE, FLAT PLATE
Suresh M. Joshi (Vigyan Research Associates, Inc.) and Nelson J. Groom Sep. 1980 21 p refs
(NASA-TM-81887) Avail: NTIS HC A02/MF A01 CSCL 22B

A finite element structural model of a 30.48 m x 30.48 m x 2.54 mm completely free aluminum plate is described and modal frequencies and mode shape data for the first 44 modes are presented. An explanation of the procedure for using the data is also presented. The model should prove useful for the investigation of controller design approaches for large flexible space structures.
Author

N81-16091# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
OPTIMAL REGULATION WITHIN SPATIAL CONSTRAINTS. AN APPLICATION TO FLEXIBLE STRUCTURES Ph.D. Thesis - MIT
Edward Gregory Taylor Aug. 1980 319 p refs
(AD-A092547; AFIT-CI-80-46D) Avail: NTIS HC A14/MF A01 CSCL 22/2

The contribution of this research is a candidate controller architecture for application to lightly damped, flexible vehicles, where stiffness and mass are distributed parameters. The architecture acknowledges that a reduced order controller is required. Singular perturbation theory and the spatial shaping of control inputs and observation residuals are then coupled to derive an appropriate, asymptotically correct, low frequency plant representation, and a cascaded estimator/optimal regulator is used to construct a linear feedback law based on this low order model. The primary benefit of this approach is the capability to rigorously construct control laws for systems where the dimensions of the control vector, output vector, and the plant dynamics are high. Design examples are given which illustrate that the reduced order designs compare favorably to the optimal fullstate regulator.
GRA

N81-17447# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CENTRIFUGAL COMPRESSORS, FLOW PHENOMENA AND PERFORMANCE
Nov. 1980 342 p refs In ENGLISH; partly in FRENCH Papers presented at the 55th(B) Specialists' Meeting of the Propulsion and Energetics Panel of AGARD, Brussels, 7-9 May 1980
(AGARD-CP-282) Avail: NTIS HC A15/MF A01

Experimental investigations on flows in impellers and diffusers, theoretical calculations of flows in impellers, interaction between impeller and diffuser, and design experience and performance of advanced centrifugal compressors are discussed. Emphasis is on the inducer, impeller and the diffuser flow field, and on interactions between impeller and diffuser. A comprehensive survey and detailed information on design experience and centrifugal compressor performance are provided. Viscous, transonic, compressible, and three dimensional effects were studied. The influence of nonuniform flow at the rotor outlet on performance and surge margin, namely for high pressure ratio compressors, are discussed.

N81-18083 Stanford Univ., Calif.
CONTROL OF FLEXIBLE SPACECRAFT Ph.D. Thesis
John Alexander Breakwell 1980 100 p
Avail: Univ. Microfilms Order No. 8103488

A method is presented for maneuvering a flexible spacecraft from one position to another while leaving an arbitrary number of bending modes inactive at the end of the maneuver. The method combines standard fixed time LQG regulator control theory with a modal decompression of a flexible body. Further features of the method are that it uses minimum control effort and that it can be converted to a feedback form to deal with random disturbances and parameter uncertainties. Several examples are given to demonstrate the efficacy of the method, and results from a hardware experiment are presented.
Dissert. Abstr.

N81-19165*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
[illegible] CONTROL TECHNOLOGY
[illegible]olivar *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 9-18

Avail: NTIS HC A18/MF A01 CSCL 22B

The necessary controls technology required for precise attitude, shape, and pointing control of large space systems (LSS) is defined. The major controls tasks are summarized with emphasis on: (1) the selection of typical antenna and platform configurations, and the definition of models and performance requirements; (2) evaluating the applicability of state-of-the-art control techniques to the control of large antennas and platforms; and (3) identifying the need for and initiating the development of advanced control concepts required for LSS.
R.C.T.

N81-19166*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED CONTROL TECHNOLOGY FOR LSST ANTENNAS
Y. H. Lin *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 19-30

Avail: NTIS HC A18/MF A01 CSCL 22B

The control technology for the realization of large space system technology (LSST) antenna systems was identified and developed. Emphasis was directed at the control of LSST wrap-rib offset-feed antenna. The overall dynamic and control performance of offset-feed antenna was evaluated. Quantitative definitions of control problems were provided and control concepts for future development were identified.
R.C.T.

N81-19167*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED CONTROL TECHNOLOGY FOR LSST PLATFORM
R. S. Edmunds *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 31-48

Avail: NTIS HC A18/MF A01 CSCL 22B

Basic technology in the design, mechanization, and analysis of control systems for large flexible space structures was examined. The focus of the platform control effort was on pointing control. The reason for this emphasis was because of the unique problems in this area posed by multiple independent experiment packages operating simultaneously on a single platform. Attitude control and stationkeeping were also addressed for future consideration.
R.C.T.

N81-19180*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL TECHNOLOGY DEVELOPMENT
G. Rodriguez *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 49-64

Avail: NTIS HC A19/MF A01 CSCL 22B

Static and dynamic control design approaches were developed for distributed parameter systems. A hardware flexible beam facility was constructed to demonstrate and verify the theoretical control concepts. Efforts were made in the area of model order estimation for control systems with uncertain or time varying parameters. R.C.T.

N81-19189*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL SELF-PULSED LASER SURFACE MEASUREMENT SYSTEM DEVELOPMENT
Martin Berdahl *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 339-348

Avail: NTIS HC A19/MF A01 CSCL 22B

Distances from a fixed reference or scan postion to several locations on the surface of an antenna reflector can be measured by using a self pulsed laser ranging system. Processing the information thus obtained is used to define the shape of the surface upon which antenna operational efficiency is direcly dependent. Operation of the system consists of initiating a pulse from the laser emitter which is pointed at the scan mirror. The emitted pulse strikes the scan mirror, is reflected and sent to one of several targets on the surface of the antenna. Upon reflection from the target, the pulse returns to a detector via the scan mirror. The detected pulse is amplified and used to trigger the next emitted pulse. After the first pulse is emitted, received and used to trigger another pulse the process becomes repetitive with a repitition rate uniquely determined by the distance traveled to the target and back. A measure of the repetition rate or frequency thus created provides the means required for determining range since the total distance traveled is inversely proportional to the frequency. A.R.H.

N81-19196*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SURFACE ACCURACY MEASUREMENT SENSOR FOR DEPLOYABLE REFLECTOR ANTENNAS
R. B. Spiers, Jr. *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 439-448 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

The breadboard surface accuracy measurement sensor is an optical angle sensor which provides continuous line of sight position measurements of infrared source targets placed strategically about the antenna surface. Measurements of target coordinates define the surface figure relative to a reference frame on the antenna. Sensor operation, tests and test results to date are described. A.R.H.

N81-19198*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL THEORETICS FOR LARGE STRUCTURAL SYSTEMS
In its The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 17-34
Avail: NTIS HC A09/MF A01 CSCL 22B

The areas of research addressed include modeling identification for both the purposes of analysis and controls, design of structural control systems actuator sensor placement, and distributed sensing and actuation as opposed to co-located sensor and actuators. Also investigated are adaptive/learning processes that could more specifically be referred to as inflight testing procedures where a structure is tested during its deployment or assembly and during its orbital life at specific points where the characteristics of the structure for the purpose of tuning the control system are identified. Another area is redundancy management techniques for structural systems. This is important because of the reliability issue for managing multiple very large numbers of sensors and actuators. E.D.K.

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05
ELECTRONICS

Includes techniques for power and data distribution.

A81-25053 **An assessment of the atmospheric effects of a Satellite Power System.** D. M. Rote, K. L. Brubaker, J. Lee, and A. R. Valentino (Argonne National Laboratory, Argonne, Ill.). In: Alternative energy sources II; Proceedings of the Second Miami International Conference, Miami Beach, Fla., December 10-13, 1979. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1981, p. 1163-1191. 36 refs.

Assuming the elements of a reference Satellite Power System (SPS) created by NASA, the general environmental consequences and specific atmospheric effects of the Heavy Lift Launch Vehicle needed for its construction are assessed. Beginning with the troposphere, potential atmospheric effects such as weather modification, and the present understanding of them, are summarized as a function of altitude. Although all levels of the atmosphere will be affected, it is thought that its progressive rarefication with increasing altitude will attenuate the rocket effluent and acoustical energy impacts of the HLLV's two daily flights over a period of 30 years and the rectenna waste heat release of the microwave power transmission system. O.C.

A81-25058 **Solar energy power generators with advanced thermionic converters for spacecraft applications.** S. Sahin (Lausanne, Ecole Polytechnique Fédérale, Lausanne, Switzerland). In: Alternative energy sources II; Proceedings of the Second Miami International Conference, Miami Beach, Fla., December 10-13, 1979. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1981, p. 1253-1266. 25 refs.

Space solar energy power generators (SEPGs) using a proposed solar energy advanced thermionic converter (SEATC) are discussed, with detailed attention given to a 50 kWel solar energy generator in a geostationary orbit for direct TV-broadcasting and a 10 GWel space power plant. Basic engineering outlines are presented for both projects, each using a SEATC whose optimal operating temperatures range from 1100 to 1600 K with parabolic Fresnel mirrors as solar energy concentrators. The mirror concentration ratios may reach up to 10,000 with temperatures up to 4000 K. SEPGs with ordinary converters and those with SEATCs are compared. A comparison of the SEATC with the spacecraft thermionic reactor is also presented. D.K.

N81-18548*# Boeing Aerospace Co., Seattle, Wash.
SPS FIBER OPTIC LINK ASSESSMENT
T. O. Lindsey and E. J. Nalos *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 154-158

Avail: NTIS HC A16/MF A01 CSCL 10A

Fiber optic technology was tentatively selected in the SPS baseline design to transmit a stable phase reference throughout microwave array. Over a hundred thousand microwave modules are electronically steered by the phase reference signal to form the power beam at the ground receiving station. The initially selected IF distribution frequency of the phase reference signal was at 980 MHz or a submultiple of it. Fiber optics offers some significant advantages in view of the SPS application. Optical transmission is highly immune to EMI/RFI, which is expected to be severe when considering the low distribution power. In addition, there are savings in both mass, physical size, and potentially in cost. T.M.

N81-19193*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RADIO FREQUENCY PERFORMANCE PREDICTIONS FOR THE HOOP/COLUMN POINT DESIGN
Thomas G. Campbell *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 407-430

Avail: NTIS HC A19/MF A01 CSCL 22B

Preliminary antenna pattern tests were conducted to determine if catastrophic effects were produced by cables (conducting) in the aperture. This test consisted of an apex feed illuminating a 3 meter solid reflector. A hoop/column configuration was used in positioning the various wires and cables. Radiation patterns were measured at 7 GHz and 10 GHz. No catastrophic effects were observed for this configuration, but additional tests are required to determine the effects for more precision multiple-beam applications. In order to better understand the scattering and blockage effects on multiple beam performance, a 35 GHz model was used to model somewhat a single quad aperture configuration. Experimental results using this models are presented in graphs. A.R.H.

N81-19204*# Astro Research Corp., Carpinteria, Calif.
DESIGN CONCEPTS FOR LARGE ANTENNA REFLECTORS
John M. Hedgepeth *In* **NASA. Langley Center The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 103-119 refs**
Avail: NTIS HC A08/MF A01 CSCL 22B

A type of antenna reflector was studied in which a stiff structure is constructed to hold a membrane like reflector mesh in the correct position. An important basic restriction is that the mesh be controlled only by the structure and that no additional local shaping be employed. Furthermore, attention is confined to structures in which no adjustments would be made on assembly. Primary attention is given to the tetrahedral truss configuration because of its outstanding stiffness and dimensional stability.
E.D.K.

N81-19205*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
A MODULAR APPROACH TOWARD EXTREMELY LARGE APERTURES
A. A. Woods, Jr. *In* **NASA. Langley Research Center The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 121-143 ref**
Avail: NTIS HC A09/MF A01 CSCL 22B

Modular antenna construction can provide a significant increase in reflector aperture size over deployable reflectors. The modular approach allows reflective mesh surfaces to be supported by a minimum of structure. The kinematics of the selected deployable design approach were validated by the subscale demonstration model. Further design refinements on the module structural/joints and design optimization on intermodule joints are needed. E.D.K.

N81-19206*# General Dynamics/Convair, San Diego, Calif.
MODULAR REFLECTOR CONCEPT STUDY
D. H. Vaughan *In* **NASA. Langley Research Center The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 145-169**

Avail: NTIS HC A09/MF A01 CSCL 22B

The feasibility was studied of constructing large space structures, specifically a 100 meter paraboloidal R.F. reflector, by individually deploying a number of relatively small structural modules, and then joining them to form a single large structure in orbit. The advantage of this approach is that feasibility of a large antenna may be demonstrated by ground and flight tests of several smaller and less costly subelements. Thus, initial development costs are substantially reduced and a high degree of reliability can be obtained without commitment to construction of a very large system. The three candidate structural concepts investigated are: (1) the deployable cell module; (2) the

paraboloidal extendable truss antenna adapted to modular assembly; and (3) the modular extendable truss antenna (META).

E.D.K.

N81-19287*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ELECTROMAGNETIC ANALYSIS FOR LARGE REFLECTOR ANTENNAS

M. C. Bailey *In its* The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 171-183

Avail: NTIS HC A08/MF A01 CSCL 22B

A comparison is made between the measured E and H plane patterns of the 35 GHz offset paraboloidal reflector and the calculated patterns for the same reflector using the 200 points to describe the surface. The accuracy of the computer prediction is quite good considering that the only description of the surface was the coordinates of a finite number of points on the reflector. The results indicate the possibility of acceptable accuracy in the prediction of electromagnetic performance for arbitrarily distorted reflectors using the coordinates of a practical number of measured points. An optimization of the number and distribution of points, and experimental verification for a distorted reflector are planned.

E.D.K.

N81-19394*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

ELECTRICAL ROTARY JOINT APPARATUS FOR LARGE SPACE STRUCTURES Patent Application

Robert R. Belew and Richard J. Boehme, inventors (to NASA) Filed 4 Feb. 1981 19 p

(NASA-Case-MFS-23881-1; US-Patent-Appl-SN-231543) Avail: NTIS HC A02/MF A01 CSCL 09C

A structural array and electrical rotary joint for transmitting an electrical power between large space structures having relative rotational movement therebetween is disclosed as including large support framework structures which rotate relative to one another about a common axis of rotation. The arrangement of cylindrical hub members and associated support structure in combination with the electrical conductor and bearings enable transmission of large amounts of electrical power from structures such as a solar array to a microwave antenna while maintaining a high degree of dimensional stability.

Author

06
ADVANCED MATERIALS

Includes matrix composites, polyimide films and thermal control coatings, and space environmental effects on these materials.

A81-15977 * **Future requirements for advanced materials.** W. B. Olstad (NASA, Washington, D.C.). *(American Ceramic Society, Annual Conference on Composites and Advanced Materials, 4th, Cocoa Beach, Fla., Jan. 20-24, 1980.) Ceramic Engineering and Science Proceedings*, vol. 1, no. 7-8 (B), July-Aug. 1980, p. 495-499.

Recent advances and future trends in aerospace materials technology are reviewed with reference to metal alloys, high-temperature composites and adhesives, tungsten fiber-reinforced superalloys, hybrid materials, ceramics, new ablative materials, such as carbon-carbon composite and silica tiles used in the Shuttle Orbiter. The technologies of powder metallurgy coupled with hot isostatic pressing, near net forging, complex large shape casting, chopped fiber molding, superplastic forming, and computer-aided design and manufacture are emphasized. V.L.

A81-18388 **Material and structural approaches for large space structures.** J. F. Garibotti, R. Johnson, Jr., and A. J. Cwiertny, Jr. (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-G-297*. 15 p. 6 refs.

Material development studies and structural evaluations made in order to develop a composite geodetic beam and a beam buildup machine for in-orbit construction of large space structures towards the year 2000 are presented. Earth-prefabricated graphite-glass thermoplastic rods with a near-zero coefficient of thermal expansion and low distortion are described, giving test results for compression, torsion and shear. Thermal control coatings to minimize rod degradation are also discussed and finally, possible applications to precision reflectors and antennas are noted. N.D.

A81-19832 * **Characteristics of edge breakdowns on Teflon samples.** E. J. Yadlowsky, R. C. Hazelton, and R. J. Churchill (Kollmorgen Research and Development Center, Radford, Va.). *(IEEE, U.S. Defense Nuclear Agency, Jet Propulsion Laboratory, and DOE, Annual Conference on Nuclear and Space Radiation Effects, 17th, Ithaca, N.Y., July 15-18, 1980.) IEEE Transactions on Nuclear Science*, vol. NS-27, Dec. 1980, p. 1765-1769. 5 refs. Grant No. NsG-3145.

The characteristics of electrical discharges induced on silver-backed Teflon samples irradiated by a monoenergetic electron beam have been studied under controlled laboratory conditions. Measurements of breakdown threshold voltages indicate a marked anisotropy in the electrical breakdown properties of Teflon: differences of up to 10 kV in breakdown threshold voltage are observed depending on the sample orientation. The material anisotropy can be utilized in spacecraft construction to reduce the magnitude of discharge currents. V.L.

A81-20781 * # **A gravity gradient stabilized solar power satellite design.** M. L. Bowden (MIT, Cambridge, Mass.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0362*. 9 p. 8 refs. Grant No. NAGW-21.

The concept of a solar power satellite (SPS) is reviewed, and a design proposed for such a satellite taking advantage of solar radiation pressure and gravity gradient forces to eliminate much of the structure from the baseline configuration. The SPS design consists of a solar cell array lying in the orbital plane and a free floating mirror above to reflect sunlight down onto it. The structural modes of the solar cell array are analyzed and found to be well within control limitations. Preliminary calculations concerning the free floating mirror and its position-keeping propellant requirements are also performed. A numerical example is presented, which shows that, even in terms of mass only, this configuration is a competitive design when compared to the conventional Department of Energy reference design. Other advantages, such as easier assembly in orbit, lower position-keeping propellant requirements, possibilities for decreasing necessary solar cell area, and longer solar cell life, may make this design superior. (Author)

A81-20851 **Resins for aerospace; Proceedings of the Symposium, Honolulu, Hawaii, April 3-6, 1979.** Symposium sponsored by the American Chemical Society and Chemical Society of Japan. Edited by C. A. May (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). Washington, D.C., American Chemical Society (ACS Symposium Series, No. 132), 1980. 510 p. $48.

The symposium focuses on resin chemistry, adhesives, coatings, and sealants, reinforced plastics, and instrumental characterization technology. Papers are presented on the status of high-temperature laminating resins and adhesives, waterborne polymers for aircraft coatings, solvent-removable coatings for electronic applications, and structure-property relations of composite matrices. Other papers include a new polyester matrix system for carbon fibers, dynamic fracture in aerospace high polymers, and experimental analysis of hydrothermal aging in fiber-reinforced composites. V.L.

A81-20884 * # **Characterization of aging effects of LARC-160.** P. R. Young and G. F. Sykes (NASA, Langley Research Center, Hampton, Va.). In: Resins for aerospace; Proceedings of the Symposium, Honolulu, Hawaii, April 3-6, 1979.
Washington, D.C., American Chemical Society, 1980, p. 479-490. 5 refs.

Specimens of freshly prepared polyimide precursor resin LARC-160 and resin aged at room temperature up to 45 days were characterized by high-pressure liquid chromatography and several different thermal analyses. Graphite reinforced composites were then fabricated from fresh and aged resin and tested to determine if changes observed by these techniques were significant. It was found that resin aging resulted in greater flow during processing and poorer composite isothermal stability. However, aging did not affect the room-temperature flexural or short-beam-shear strengths of the composites. V.L.

A81-22636 **The 1980's - Payoff decade for advanced materials; Proceedings of the Twenty-fifth National Symposium and Exhibition, San Diego, Calif., May 6-8, 1980.** Symposium sponsored by the Society for the Advancement of Material and Process Engineering. Azusa, Calif., Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 25), 1980. 786 p. $55.

The symposium focuses on recent developments in advanced structural materials and adhesive formulations, material characterization, processing techniques, design and fabrication of composite structures, testing methods, and applications. Papers are presented on the advanced composite hardware utilized on the Intelsat V spacecraft, the development of advanced structural materials for fusion power, an instrumented tensile impact method for composite materials, and prospects for bonding primary aircraft structures in the 80's. V.L.

BEST DOCUMENT AVAILABLE

A81-22643 Thermal control film bonding for space applications. J. M. Kwan and D. T. Chow (Hughes Aircraft Co., Technology Support Div., Culver City, Calif.). In: The 1980's - Payoff decade for advanced materials; Proceedings of the Twenty-fifth National Symposium and Exhibition, San Diego, Calif., May 6-8, 1980. Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1980, p. 103-114.

An overview is presented op the process difficulties of several state-of-the-art adhesives commonly used for thermal film bonding. A silicone pressure sensitive adhesive tape was evaluated as an alternative to replace these conventional adhesives. The test program involved the determination of optimum parameters for the bonding process and the measurement of various physical properties such as outgassing, glass transition temperature, adhesion to various substrates, high and low temperature survivability, and resistance to thermal cycling and humidity environment. (Author)

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N81-10086*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE ENVIRONMENTAL EFFECTS ON MATERIALS
R. J. Schwinghmaer Aug. 1980 52 p refs
(NASA-TM-78306) Avail: NTIS HC A04/MF A01 CSCL 22B

The design of long life platforms and structures for space is discussed in terms of the space environmental effects on the materials used. Vacuum, ultraviolet radiation, and charged particle radiation are among the factors considered. Research oriented toward the acquisition of long term environmental effects data needed to support the design and development of large low Earth orbit and geosynchronous Earth orbit space platforms and systems is described. J.M.S.

N81-12078# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter Div.
SPACE STRUCTURE TODAY AND TOMORROW
M. Brunsch Paris Association Aeronautique et Astronautique de France 1979 13 p
(AAAF-NT-79-46; ISBN-2-7170-0594-3) Avail: NTIS HC A02/MF A01; CEDOCAR, Paris FF 22 (France and EEC) FF 27 (others)

The cost effectiveness of carbon fiber composites for aerospace structures is analyzed. Strength to volume ratio, satellite launching cost per unit weight, raw to finished material ratio, evaluation of material properties in space environment, advantage of a low expansion coefficient, and advantages for space construction are discused. It is concluded that carbon fiber composites present both technological advantages and cost effectiveness. Two examples of applications to aircraft structures are described. Author (ESA)

N81-12184# Centre National d'Etudes Spatiales, Toulouse (France).
COMPOSITE MATERIALS APPLIED TO AEROSPACE STRUCTURES
J. N. Giraudbit Paris Association Aeronautique et Astronautique de France 1979 51 p In FRENCH; ENGLISH summary Presented at 14th. Intern. AAAF Aeron. Congr. on New Develop. in Struct. and Mater., Paris, 6-8 Jun. 1979
(AAAF-NT-79-45; ISBN-2-7170-0593-5) Avail: NTIS HC A04/MF A01; CEDOCAR, Paris FF 34 (France and EEC) FF 39 (others)

The specific advantages of the use of carbon fiber reinforced plastics (CFRP) in aerospace structures such as antenna systems and telescope structures are reviewed. In addition to good mechanical performance low or even zero coefficient of thermal expansion is a practical necessity in the design of these components. The manufacturing processes are discussed. Practical examples of the applications of CFRP in the Spot, Intelsat 5, MAROTS and LST satellites are presented. Author (ESA)

N81-19092*# Pennsylvania State Univ., University Park. Dept. of Electrical Engineering.
SECONDARY ELECTRON EMISSION FROM ELECTRICALLY CHARGED FLUORINATED-ETHYLENE-PROPYLENE TEFLON FOR NORMAL AND NON-NORMAL ELECTRON INCIDENCE M.S. Thesis
Paul Arthur Budd Mar. 1981 147 p refs
(Grant NsG-3166)
(NASA-CR-163968) Avail: NTIS HC A07/MF A01 CSCL 20L

The secondary electron emission coefficient was measured for a charged polymer (FEP-Teflon) with normally and obliquely incident primary electrons. Theories of secondary emission are reviewed and the experimental data is compared to these theories. Results were obtained for angles of incidence up to 60 deg in normal electric fields of 1500 V/mm. Additional measurements in the range from 50 to 70 deg were made in regions where the normal and tangential fields were approximately equal. The initial input angles and measured output point of the electron beam could be analyzed with computer simulations in order to determine the field within the chamber. When the field is known, the trajectories can be calculated for impacting electrons having various energies and angles of incidence. There was close agreement between the experimental results and the commonly assumed theoretical model in the presence of normal electric fields for angles of incidence up to 60 deg. High angle results obtained in the presence of tangential electric fields did not agree with the theoretical models. M.G.

N81-19172*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RADIATION EXPOSURE OF SELECTED COMPOSITES AND THIN FILMS
Wayne S. Slemp and Beatrice Santos *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 105-118

Avail: NTIS HC A19/MF A01 CSCL 22B

The effect of electron radiation on selected candidate composite materials was investigated. Radiation damage mechanisms were identified and the coefficient of thermal expansion were measured for each type composite material. It was concluded that the threshold for major physical and mechanical property changes in the polysulfone films and in the polysulfone and epoxy composites is in excess of 1 x 10 to the 9th power rads of electrons. Based upon these data, the 5208 and 934 epoxies and the P1700 polysulfone composites would be acceptable for 5 to 10 year geosynchronous Earth environment missions receiving < 1 x 10 to the 9th power rads of electron radiation. R.C.T.

N81-19173*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMAL EXPANSION OF COMPOSITES: METHODS AND RESULTS
David E. Bowles and Darrel R. Tenney *In its* Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 119-128 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

The factors controlling the dimensional stability of various components of large space structures were investigated. Cyclic, thermal and mechanical loading were identified as the primary controlling factors of the dimensional stability of cables. For organic matrix composites, such as graphite-epoxy, it was found that these factors include moisture desorption in the space environment, thermal expansion as the structure moves from the sunlight to shadow in its orbit, mechanical loading, and microyielding of the material caused by microcracking of the matrix material. The major focus was placed on the thermal expansion of composites and in particular the development and testing of a method for its measurement. R.C.T.

07
ASSEMBLY CONCEPTS

Includes automated manipulator techniques, EVA, robot assembly, teleoperators, and equipment installation.

A81-11351 **Hardhats in space.** F. W. Haise, Jr. (Grumman Aerospace Corp., Bethpage, N.Y.). *Grumman Aerospace Horizons,* vol. 16, no. 1, 1980, p. 8-15.

Methods and materials for constructing space satellite projects are discussed. By the end of the century, workers in space would be able to assemble structures weighing up to millions of earth pounds. Stations could be constructed to produce pharmaceuticals and other items, which are impossible to manufacture on earth. A space shuttle orbiter with a cargo bay 15 ft in diameter and 60 ft long could carry a payload of more than 32 tons and support a crew in orbit for a week in the initial stages of construction. A full-scale machine has been developed that fabricates a triangular one meter structural beam of varying lengths, which could serve as the framework for an orbiting antenna satellite. Space workers would be assisted in assembly work or repair jobs by manned remote work stations, known as open and closed cherry-pickers. Plans for a solar satellite that is 12 miles long and 3 miles wide and which could deliver 5,000 megawatts into the electric power grid on earth are also discussed.

R.C.

A81-18245 **A construction of Geostationary Space Platform /GSP/ using a rendezvous docking technique.** T. Tadakawa and M. Saito (National Space Development Agency of Japan, Rocket Technology Laboratory, Sakura, Ibaraki, Japan). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-36.* 16 p. 12 refs.

A study for a projected Japanese Geostationary Space Platform (GSP) for the 1990's is presented. The GSP is a three-axis stabilized satellite consisting of six payloads and of supporting subsystems (bus module). It will be primarily used for communication in the C and K bands for intersatellite links, navigation and direct TV broadcast. The mission payloads will be seperately launched and then assembled in orbit by a teleoperator. The lifetime is approximately 10 years, the payload weight is 230 kg and the power is 1200 W. Technical design details are covered and future research problems are pointed out.

N.D.

A81-18246 * **Construction and assembly of large space structures.** J. W. Mar, R. H. Miller, and M. L. Bowden (MIT, Cambridge, Mass.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-37.* 11 p. 7 refs. Grant No. NAGW-21.

Three aspects of the construction and assembly of large space structures, namely transportation costs, human productivity in space and the source of materials (lunar vs terrestrial), are considered. Studies on human productivity have been so encouraging that the cost of human labor is now regarded as much less important than transportation costs. It is pointed out that these costs, although high, are extremely demand-sensitive. Even with high demand, however, the construction of several large systems would warrant the use of lunar materials and space manufacturing. The importance of further research is stressed in order to establish the optimum tradeoff between automation and manual assembly. C.R.

A81-18248 **The role of man in the space construction of large structures.** E. Katz and J. A. Roebuck (Rockwell International Corp., Space Operations and Satellite Systems Div., Downey, Calif.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-39.* 11 p. 12 refs. (SSD-80-0127)

The paper focuses on the role of a man in the construction of large space structures. The operation of a remote manipulation system (RMS) by crewmen located in the aft flight deck station of a Shuttle orbiter is analyzed. Although the RMS is a faster and more appropriate handling method than extravehicular activity (EVA) for the massive construction equipment element, some construction functions will still require an EVA astronaut stationed on a maneuverable platform because the need for detailed visibility of the construction operations and for direct access, manipulation, and positioning of piece-parts will make an EVA astronaut indispensable. It is recognized, however, that EVA poses increased hazards to the crew and consequently a more advanced EVA suit is required. Explanatory diagrams and detailed work schedules are included.

C.R.

A81-18249 **Manned elements to support the establishment of large systems in space.** E. Vallerani (Aeritalia S.p.A., Settore Spazio, Turin, Italy). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-40.* 23 p. 16 refs.

The paper examines the concept of the Manufacturing and Maintenance Module (MMM), a system which will support the assembly of large structures in space and perform their maintenance. The pressurized cabin of the MMM derived from the Spacelab Module will be associated with a system of manipulators, cranes, and various tools. The system is conceived to be absolutely autonomous, capable of operating for long periods of time in the proximity of the space station it is servicing. The MMM is a mobile unit devoted only to workshop activities, while other services, such as crew housing, power generation, and earth communications, are supplied by the space station. V.L.

A81-21085 # **A comparison of natural frequency prediction methods for flexible manipulator arms.** W. J. Book and M. Majette (Georgia Institute of Technology, Atlanta, Ga.). *American Society of Mechanical Engineers, Winter Annual Meeting, Chicago, Ill., Nov. 16-21, 1980, Paper 80-WA/DSC-19.* 13 p. 6 refs. Members, $2.00; nonmembers, $4.00.

Predictions of natural frequencies of flexible manipulator arms as performed by alternative structural models and computer implementations are compared. The Space Shuttle Remote Manipulator System (RMS) manipulator arm is used as the basis for comparison. Finite element and transfer matrix implementations of Bernoulli Euler, lumped mass, and consistent mass models are considered.

(Author)

A81-22609 # **Teleoperator Orbital Transportation System.** R. A. Spencer (Martin Marietta Aerospace, Denver Div., Denver, Colo.) and J. R. Towell (Martin Marietta Aerospace, New Orleans, La.). In: Association for Unmanned Vehicle Systems, Annual Technical Symposium, 7th, Dayton, Ohio, June 16-18, 1980, Proceedings. Dayton, Ohio, Association for Unmanned Vehicle Systems, 1980, p. 51-58. 9 refs.

The STS Teleoperator Maneuvering System (TMS) is described. The heart of the TMS is a small compact three-axis remotely controlled spacecraft, which is capable of placing satellites into orbit with later prospects of revisit and/or retrieval. This free-flying core vehicle uses a simple block buildup approach that allows a variety of add-on kits to be attached to the core to satisfy design constraints, additional mission performance, special control modes, and unique mission services. The systematic buildup of modular subsystems minimizes the TMS front-end design costs and the associated STS launch costs. B.J.

A81-22757 * # **Space construction technology needs.** L. M. Jenkins (NASA, Johnson Space Center, Program Development Office, Houston, Tex.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0442.* 5 p. 9 refs.

Space construction systems made feasible by an operational Space Shuttle are discussed with a view toward assembly, installation and construction support equipment. The level of construction capability will be reflected in the number of launches to accomplish a certain mission, either in terms of the mission time line or on the density of packaging in the Orbiter payload bay. It is noted that the development of construction support equipment in zero-gravity simulations should be the most productive initial activity. Crew EVAs, as well as the beam builder, cherrypicker and power distribution buses are covered in detail. L.S.

A81-22761 * # **A concept for high speed assembly of erectable space platforms.** H. Cohen, G. G. Jacquemin, and R. R. Johnson (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0446.* 9 p. 7 refs. Contract No. NAS1-15240.

A simple, fully automatic assembler associated with the on-orbit assembly of tetrahedral truss platforms erected of graphite epoxy tapered columns is described. The assembler, which can operate either as a free flyer or attached to the Orbiter, is capable of constructing a platform from a full load of truss columns and node joints in 36 hours. The geometry of this electrically-driven machine is based on a compound parallelogram system which permits backward as well as lateral translations. Concepts have been developed for half-column assembly as well as for column and node joint insertion into the platform. (Author)

A81-22768 # **Satellite assembly in geostationary orbit - A concept for a cost effective communication satellite applications platform.** A. W. Preukschat (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0459.* 10 p. 9 refs.

Two concepts for a Large Communication Space Segment (LCSS) at a single position are outlined. The LCSS would replace a number of individual communication satellites occupying geostationary orbit positions. Specific objectives for future European communication space platforms are given with a view toward space segment construction in geostationary orbit. The basic design of a European Satellite Assembly System is presented in terms of its technical characteristics. The ESAS concept achieves launch vehicle compatibility without reduction of reliability or total mass. A 'horizontal separation' of the functional modules of a communication satellite is proposed to separate service module and payload module. It is shown that the cost-effectiveness of ESAS relative to conventional dual-satellite space segments is generally favorable. L.S.

A81-23045 * **Composite beam builder.** L. M. Poveromo, W. K. Muench, W. Marx, and G. Lubin (Grumman Aerospace Corp., Bethpage, N.Y.). *SAMPE Journal*, vol. 17, Jan.-Feb. 1981, p. 7-15. NASA-supported research.

The building block approach to large space structures is discussed, and the progress made in constructing aluminum beams is noted. It is pointed out that composites will also be required in space structures because they provide minimal distortion characteristics during thermal transients. A composite beam builder currently under development is discussed, with attention given to cap forming and the fastening of cross-braces. The various composite materials being considered are listed, along with certain of their properties. The need to develop continuous forming stock up to 300 m long is stressed.

C.R.

A81-24745 # **Construction in space - Neutral buoyancy simulation of EVA assembly.** D. L. Akin (MIT, Cambridge, Mass.). *AIAA Student Journal*, vol. 18, Summer 1980, p. 4-10.

A neutral buoyancy simulation of the on-orbital assembly of large space structures by astronauts engaging in extravehicular activity is discussed. The simulation was part of a program to obtain quantitative estimates of the productivity of space construction workers. The program consisted of four phases, including the derivation of an analytical model of the human body performing typical assembly motions, the validation of the model by underwater tests, determination of the conditions under which a neutral buoyancy simulation would accurately model weightlessness, and the performance of simulated assembly to estimate zero-g productivity. Simulated assembly tasks performed in pressure suits initially required considerably more time than those performed underwater without the suits or on dry land, however with continued experience, learning rates from 63 to 71% were obtained. The construction of complex structures by two-person teams resulted in times twice that of the unsuited activity, and productivities up to 627 kg/hr, an order of magnitude greater than for earth-based analogs. An experiment to quantify the effects of fatigue on productivity was also performed. Results demonstrate the feasibility of extravehicular assembly, particularly for medium- or large-sized space structures. S.C.S.

A81-24829 **Automated beam builder update.** W. K. Muench (Grumman Aerospace Corp., Bethpage, N.Y.). *Space Solar Power Review*, vol. 1, no. 4, 1980, p. 299-316.

Early in 1977, Grumman Aerospace Corporation was awarded a contract to design, develop, manufacture and test a machine which would automatically produce a basic building block aluminum beam. This ground demonstration beam builder was delivered to NASA-MSFC in October, 1978 where it is in operation today producing aluminum beams for structural static and dynamic tests, neutral buoyancy structural assembly simulations, and other demonstrational purposes. From mid-1977 to the present, Grumman, having recognized the need for composite beams, has been conducting various significant critical technological process development tests required to produce an automated composite beam builder. Both these efforts and their current status are discussed in this paper.

(Author)

A81-26412 # **Problems of assembly and support of objects in space (Nekotorye problemy sborki i obsluzhivaniia ob'ektov v kosmose).** I. T. Beliakov and Iu. D. Borisov. In: Scientific lectures in aviation and astronautics 1978. Moscow, Izdatel'stvo Nauka, 1980, p. 94-99. In Russian.

Consideration is given to problems associated with the assembly, maintenance, and engineering support of space stations. A general approach to the design of assembly and support equipment is described. B.J.

N81-19179*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE ASSEMBLY METHODOLOGY
J. W. Stokes and H. H. Watters *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 199-216
Avail: NTIS HC A19/MF A01 CSCL 22B

Large space structure assembly analysis techniques are defined and simulation activities are described. The simulations included are: an extravehicular activity assembly simulation; a fabricated beam assembly series using a beam generating machine and caps, and cross beam brackets; deployment of a deployable truss, using the neutral buoyancy remote manipulator system with crewman assistance; and a series aboard the KC-135 zero g aircraft. M.G.

N81-19180*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
CONSTRUCTION ASSEMBLY AND OVERVIEW
Lyle M. Jenkins *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 217-228

Avail: NTIS HC A19/MF A01 CSCL 22B

The graphite composite forming and welding technologies for the beam builder concept are discussed. Testing of the prototype truss segment and requirements for orbiter based construction equipment concepts are briefly addressed. M.G.

N81-19202*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

AUTOMATED INSTALLATION OF LARGE PLATFORM UTILITIES

R. M. Vernon *In* NASA. Langley Research Center The 1980 Large Space Systems Technol., Vol. 2 Feb. 1981 p 71-88 refs

Avail: NTIS HC A09/MF A01 CSCL 22B

The capabilities of the assembler in installing nonstructural platform systems were assessed. These systems include electrical power distribution, heat transport, command and data signal transmission, and payload data transmission. The effects of including installation of utilities on the assembly process and on the design, operation, and performance of the assembler were evaluated. In addition, any special requirements on the assembler and/or the platform due to the installation of utilities were identified. The procedure followed was to define a set of candidate utility characteristics and installation requirements, define and design installation concepts, and perform an assessment of impacts on the assembler and its operation. E.D.K.

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08
PROPULSION

Includes propulsion designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.

A81-15885 # **Orbit transfer propulsion and large space systems.** K. E. Kunz (Rockwell International Corp., Space Operations and Satellite Systems Div., Downey, Calif.). *Journal of Spacecraft and Rockets*, vol. 17, Nov.-Dec. 1980, p. 495-500. 7 refs.

An overall comparison of the relative merits of various types of propulsion systems is made for the orbit transfer of an advanced communications space platform from low earth orbit to geosynchronous equatorial orbit. Structural/propulsive interactions are examined; significant propulsion requirements are deduced; and some concepts are illustrated with design characteristics. The structural/propulsive interactions consist of the total weight sensitivity to the thrust/weight ratio, the structural load amplification factor sensitivity to the thrust buildup rise time, and the location and arrangement concepts to obtain thrust vector control and enhance T/W control. A cluster of cryogenic modules appears to be superior in that fewer modules and launches are required than for either the storable propellant or solid propellant modules. B.J.

A81-29567 * # **Performance capabilities of the 8-cm Mercury ion thruster.** M. A. Mantenieks (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, Japan Society for Aeronautical and Space Sciences, and DGLR, International Electric Propulsion Conference, 15th, Las Vegas, Nev., Apr. 21-23, 1981, AIAA Paper 81-0754.* 9 p. 11 refs.

The paper presents an initial characterization of the performance capabilities and constraints of the 8-cm Hg ion thruster system with a view to evaluating its application to large space system propulsion requirements. With minor thruster modifications, the thrust was increased by about a factor of four, while the discharge voltage was reduced from 39 to 22 volts. The thruster was operated over a range of specific impulse of 1950 to 3040 seconds, and a maximum total efficiency of about 54% was attained at a discharge voltage of 24 volts and thruster input power of 0.49 kW. V.L.

A81-29572 # **The application of ion propulsion to the transportation and control of solar power satellites.** D. G. Fearn (Royal Aircraft Establishment, Farnborough, Hants., England). *AIAA, Japan Society for Aeronautical and Space Sciences, and DGLR, International Electric Propulsion Conference, 15th, Las Vegas, Nev., Apr. 21-23, 1981, AIAA Paper 81-0760.* 13 p. 40 refs.

It is noted that a feature common to all proposed solar power satellites is the enormous mass, approaching perhaps 100,000 tons for a 10 GW version. A survey of the methods of transporting such masses to geostationary orbit is given. It is concluded that electric propulsion techniques offer very considerable technical and financial advantages and that ion thrusters currently embody the most suitable technology. It is also demonstrated that the use of ion propulsion for attitude and orbit control would be of great benefit. An advanced form of ion thruster, offering a very high beam velocity and current density, is proposed for these applications. C.R.

N81-11101*# General Dynamics Corp., San Diego, Calif. Advanced Space Programs.

LOW THRUST VEHICLE CONCEPT STUDY Final Report

26 Sep. 1980 291 p refs

(Contract NAS8-33527)

(NASA-CR-161584; GDC-ASP-80-010) Avail: NTIS HC A13/MF A01 CSCL 22B

Low thrust chemical (hydrogen-oxygen) propulsion systems configured specifically for low acceleration orbit transfer of large space systems were defined. Results indicate that it is cost effective and least risk to combine the OTV and stowed spacecraft in a single 65 K Shuttle. The study shows that the engine for an optimized low thrust stage (1) does not require very low thrust; (2) 1-3 K thrust range appears optimum; (3) thrust transient is not a concern; (4) throttling probably not worthwhile; and (5) multiple thrusters complicate OTV/LSS design and aggravate LSS loads. Regarding the optimum vehicle for low acceleration missions, the single shuttle launch (LSS and expendable OTV) is most cost effective and least risky. Multiple shuttles increase diameter 20%. The space based radar structure short OTV (which maximizes space available for packaged LSS) favors use of torus tank. Propellant tank pressures/vapor residuals are little affected by engine thrust level or number of burns. A.R.H.

N81-18219*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A MAGNETIC MULTIPOLE LINE-CUSP ARGON ION THRUSTER

James S. Sovey 1981 12 p refs Proposed for presentation at the 15th Intern. Elec. Propulsion Conf., Las Vegas, Nev., 21-23 Apr. 1981; cosponsored by the AIAA, the Japan Soc. for Aeronautical and Space Sciences, and Deutsche Gesellschaft Fuer Luft- und Raumfahrt

(NASA-TM-81703; E-729) Avail: NTIS HC A02/MF A01 CSCL 21C

A 17 cm diameter line cusp ion thruster was evaluated with inert gases which are candidate propellants for an orbit and orbit transfer propulsion functions for Large Space Systems. A semiempirical relationship was generated to predict thruster beam current in terms of plasma parameters which would allow initial thruster optimization without ion extraction and the associated large vacuum facilities. The sensitivity of performance to changes in discharge electrode configurations and magnetic circuit was evaluated and is presented. After final optimization a propellant utilization efficiency of 0.9 at a discharge chamber power expenditure of about 280 w per beam ampere was obtained. These performance parameters are the highest yet achieved with argon propellant. Author

N81-18220*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE CAPABILITIES OF THE 8-CM MERCURY ION THRUSTER

M. A. Mantenieks 1981 13 p refs Proposed for Presentation at the 15th Intern. Elec. Propulsion Conf., Las Vegas, Nev., 21-23 Apr. 1981; cosponsored by the AIAA, the Japan Soc. for Aeronautical and Space Sciences, and Deutsche Gesellschaft Fuer Luft- und Raumfahrt

(NASA-TM-81720; E-755) Avail: NTIS HC A02/MF A01 CSCL 21C

A preliminary characterization of the performance capabilities of the 8-cm thruster in order to initiate an evaluation of its application to LSS propulsion requirements is presented. With minor thruster modifications, the thrust was increased by about a factor of four while the discharge voltage was reduced from 39 to 22 volts. The thruster was operated over a range of specific impulse of 1950 to 3040 seconds and a maximum total efficiency of about 54 percent was attained. Preliminary analysis of component lifetimes, as determined by temperature and spectroscopic line intensity measurements, indicated acceptable thruster lifetimes are anticipated at the high power level operation. T.M.

N81-21073# Messerschmitt-Boelkow G.m.b.H., Munich (West Germany). Helicopter and Transport Div.

ACTIVE VIBRATION ISOLATION SYSTEM FOR HELICOPTERS. CONCEPT STUDIES INCLUDING TESTS ON A SINGLE-AXIS LABORATORY RESEARCH MODEL Final Report

Rainer Mehlhose and Matthias Bermayer Bonn Bundesministerium fuer Forschung und Technologie Dec. 1979 213 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie

(BMFT-FB-W-79-48; ISSN-0170-1339) Avail: NTIS HC A10/MF A01

A generally applicable active vibration isolation system for

helicopters which reduces the chief blade passage harmonic rotor disturbances is discussed. Two rotor isolation concepts are examined: (1) a fully active system with active disturbance rejection; and (2) a partially active system with conventional passive vibration isolation. Both systems include an automatic trim device to reduce quasistatic displacements between the fuselage and the rotor/transmission unit. Results show that multiaxis vibration, isolation with the fully active system is definitely more efficient than with the partially active system.
Author (ESA)

N81-21122*# Aerojet Liquid Rocket Co., Sacramento, Calif.
LOW-THRUST CHEMICAL ROCKET ENGINE STUDY Final Contractor Report
J. A. Mellish Mar. 1981 152 p refs
(Contract NAS3-21940)
(NASA-CR-165278) Avail: NTIS HC A08/MF A01 CSCL 21H

Engine data and information are presented to perform system studies on cargo orbit-transfer vehicles which would deliver large space structures to geosynchronous equatorial orbit. Low-thrust engine performance, weight, and envelope parametric data were established, preliminary design information was generated, and technologies for liquid rocket engines were identified. Two major engine design drivers were considered in the study: cooling and engine cycle options. Both film-cooled and regeneratively cooled engines were evaluated. The propellant combinations studied were hydrogen/oxygen, methane/oxygen, and kerosene/oxygen. T.M.

09
FLIGHT EXPERIMENTS

Includes controlled experiments requiring high vacuum and zero G environment.

A81-22762 # **An initial step in platform construction - The USAFA foam beam space experiment.** P. A. Swan (U.S. Air Force Academy, Colorado Springs, Colo.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0447.* 6 p. 5 refs.

Three foam-beam experiments proposed for the Space Shuttle Get-Away-Special (GAS) Canister project by USAFA cadets are reviewed. The objective was to produce a metallic foam beam with homogeneous porosity and a density less than a tenth of pure metal, created with a continuous beam builder. Diagrams of the prototypes are provided. L.S.

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10
SOLAR POWER SATELLITE SYSTEM

Includes solar power satellite concepts with emphasis upon structures, materials, and controls.

A81-10492 * **Apparent luminosity of solar power satellites.** L. E. Livingston (NASA, Johnson Space Center, Houston, Tex.). *Space Solar Power Review*, vol. 1, no. 3, 1980, p. 175-190. 6 refs.

The objective of this investigation was a quantitative characterization of solar power satellite luminosity as seen from the earth. The reflective characteristics of the reference photovoltaic satellite configurations are defined. Diffuse reflection from a single satellite will, at maximum, fall between magnitudes -4 and -5. A 60-satellite fleet will have a maximum total luminosity equivalent to a single object of magnitude -9. Specular reflections from the array and antenna will be of magnitude -12 to -15, but visible only occasionally for about 2 minutes at a given location. Methods of preventing specular reflections from striking the earth are presented. Thermal cycle power conversion systems are discussed qualitatively as a means of reducing diffuse luminosity. (Author)

A81-10494 **Parameterized power satellite systems design.** R. Sperber and G. Woodcock (Boeing Aerospace Co., Seattle, Wash.). *Space Solar Power Review*, vol. 1, no. 3, 1980, p. 209-219. 6 refs.

Knowledge gained in detailed studies of power satellites allows the construction of reliable and simple parametric models for first order comparisons and evaluation. These techniques are illustrated in a comparison of several types of power satellites using both laser and microwave power transmission options. Of the laser power transmission power satellite systems, photovoltaic free electron lasers and optically pumped laser power satellites appear most attractive but still more massive and costly than microwave power transmission power satellites. In addition, relationships for sizing system power for minimum system total cost and for power-limited transmission links are developed. (Author)

A81-10495 **Optimization of antenna pairs for microwave and power transmission.** C. E. Mack, Jr. (Grumman Aerospace Corp., Research Dept., Bethpage, N.Y.) and G. Moyer (Grumman Aerospace Corp., Software Systems Dept., Calverton, N.Y.). *Space Solar Power Review*, vol. 1, no. 3, 1980, p. 221-240.

The optimum transmitting distribution function is determined for an antenna beaming microwave power from space to a ground receiver. This is accomplished by minimizing a chosen cost function for the system using the methods of optimal control theory. It is the reverse of the usual methods of analysis wherein the distribution function is specified in advance. The distribution function calculated by the procedure developed here is the square of a finite linear sum of zero-order Bessel functions, each of which is multiplied by a constant. Very simple one-term formulas result from the analyses for the radii of the two antennas and for the minimum cost itself. For any given problem, the requisite computer runs are carried out once and for all and are only a few minutes in duration. What makes the method especially attractive is that the main results are simply a function of the ratio of the power collected to that transmitted. (Author)

A81-13190 **Conditions and requirements for a potential application of solar power satellites /SPS/ for Europe.** W. Westphal, J. Ruth (Berlin, Technische Universität, Berlin, West Germany), and D. Kassing (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands). *British Interplanetary Society, Journal (Space Technology)*, vol. 33, Dec. 1980, p. 411-418.

The potential problems of a future introduction of Solar Power Satellites (SPS) as baseload power plants for Western European countries are considered, emphasizing the differences of SPS utilization in Europe compared with that in the USA as a result of geographical, orbital organizational, and industrial conditions. If estimated SPS safety zone areas are required, then the SPS system incorporating the 2.45 GHz microwave power transmission appears crucial for utilization in Western Europe in order to eliminate the large rectenna area requirements of an SPS 5 GW power system. A frequency variation of up to 5 or 10 GHz, and the application of either laser power transmission or solid state devices which could alleviate rectenna siting problems and restrictions on the use of the geosynchronous orbit are discussed. A.C.W.

A81-14084 # **The solar satellite power system as a future European energy source.** H. Stoewer, D. Kassing (ESA, Systems Engineering Dept., Noordwijk, Netherlands), and K. K. Reinhartz (ESA, Technology Dept., Noordwijk, Netherlands). *ESA Bulletin*, vol. 21, Feb. 1980, p. 8-14.

The potential of solar satellite power systems as an energy source for Europe is discussed. The current and future energy situation in Europe, which has to import 50-60% of its energy needs, is reviewed, and it is shown that a fleet of 40 solar-power satellites with an output of 5 GW each could satisfy current energy demands in all member countries of the European Economic Community. The concept of the satellite solar power system is then introduced, with consideration given to the DOE/NASA reference design and the space transportation system required to carry it into orbit. Advantages of the use of solar energy from space are discussed, and the status of SPS concept evaluations in the U.S., which have shown no definitive impedances to development, is indicated. Issues which must be addressed in the evaluation of the usefulness of solar power satellites in Europe are identified, including costs, available receiving sites, reliability, radiation levels and timeliness, and it is concluded that SPS could be a promising means for producing a significant portion of future European energy needs, although a considerable effort will be required to demonstrate its engineering, economic and environmental viability. A.L.W.

A81-18001 # **Some aspects of antenna technology for European SPS.** R. V. Gelsthorpe, B. Claydon, and A. W. Rudge (ERA Technology, Ltd., RF Technology Centre, Leatherhead, Surrey, England). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 7 p.

The paper deals with a geostationary orbiting solar power satellite (SPS) system proposed by NASA. It consists of a 50 sq km array of photovoltaic cells which utilizes solar energy to generate electric energy for transmission to earth. The reference system design employs a 1 km-diam phased array antenna powered by over 100,000 klystrons to transmit this energy to earth in the form of a highly collimated beam of microwave energy at a frequency of 2.45 GHz. This energy is intercepted by means of a ground receiving/rectifying antenna which consists of a vast number of individual dipoles. V.P.

A81-18002 * # **Solar Power Satellite /SPS/ antenna measurement considerations.** D. J. Kozakoff, J. M. Schuchardt, and J. W. Dees (Georgia Institute of Technology, Atlanta, Ga.). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 9 p. 9 refs. Contract No. NAS8-33605.

An investigation carried out by the Georgia Institute of Technology that quantified the error contributors associated with both far-field and near-field antenna measurement concepts is discussed. Measurement errors are quantified into four sources: antenna range, structural/environmental, transmitter, and receiver. The study is carried out so as to control error sources to yield an overall gain uncertainty of plus or minus 0.04 dB. With regard to antenna positioners, it is found that a small angle positioner provides highly accurate scan capability over a plus or minus 1.5 deg sector for the purpose of beam integration. With regard to near-field measurement techniques, it is found that with adequate probe calibration and precision mechanical scanning, full 30 by 30 m mechanical module antenna measurements may be performed. The performance and relative cost considerations between planar near-field and conventional far-field methods indicate that the overall costs are roughly the same. C.R.

A81-18003 # **Potential interest in Europe in SPS development.** K. K. Reinhartz (ESA, Noordwijk, Netherlands). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 7 p. 7 refs.

The Solar Satellite Power System is a concept whereby large solar-energy converters are placed in outer space and the electrical energy produced is transmitted back to earth as microwave radiation. A number of studies, performed mainly in the United States, are aimed at assessing the technical, economic, social and health aspects of this concept. This paper does not address the feasibility of the SPS as such, but discusses the potential contribution that an SPS could make to the European energy scenario, the economic impact of the SPS as an indigenous European energy source, and the potential importance of the SPS as a technology driver. A European network of forty solar power satellites could supply electrical energy equal to Europe's present electrical energy production and significantly reduce Europe's dependence on energy imports. Additionally the development of a power satellite technology, if started by the United States, is expected to lead to such an advancement in technology in key areas, e.g., space inductrialisation, photovoltaic energy conversion and wireless transmission of energy, that Europe would rapidly lose technical competence in many important fields if it were not to participate. (Author)

A81-18005 # **Microwave radiation - Biological effects and exposure standards.** I. R. Lindsay (RAF, Institute of Naval Medicine, Alverstoke, Hants., England). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 5 p. 14 refs.

The thermal and nonthermal effects of exposure to microwave radiation are discussed and current standards for microwave exposure are examined in light of the proposed use of microwave power transmission from solar power satellites. Effects considered include cataractogenesis at levels above 100 mW/sq cm, and possible reversible disturbances such as headaches, sleeplessness, irritability, fatigue, memory loss, cardiovascular changes and circadian rhythm disturbances at levels less than 10 mW/sq cm. It is pointed out that while the United States and western Europe have adopted exposure standards of 10 mW/sq cm, those adopted in other countries are up to three orders of magnitude more restrictive, as they are based on different principles applied in determining safe limits. Various aspects of the biological effects of microwave transmissions from space are considered in the areas of the protection of personnel working in the vicinity of the rectenna, interactions of the transmitted radiation with cardiac pacemakers, and effects on birds. It is concluded that thresholds for biological effects from short-term microwave radiation are well above the maximal power density of 1 mW/sq cm projected at or beyond the area of exclusion of a rectenna. A.L.W.

A81-18006 # **Satellite Power System Concept Development and Evaluation Program.** F. A. Koomanoff (U.S. Department of Energy, Satellite Power System Projects Office, Washington, D.C.). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 5 p.

The progress made by the Concept Development and Evaluation Program (CDEP), set up to consider the Satellite Power System (SPS) program, is assessed. It is pointed out that from a technical standpoint the SPS concept now has at least two options for each of the following subsystems: conversion of solar energy to electrical energy; conversion of electrical energy to radio frequency energy; power transmission to earth; transportation; and space construction and manufacturing. The environmental assessment carried out as part of the CDEP is analyzed with attention given to such questions as the effect of SPS microwaves at high power densities on humans, the climatic effect of SPS effluents and the effect of ionospheric heating on telecommunications. The societal assessment (availability of materials, land, and water) and comparative assessment (consideration of alternatives to SPS) that also enter into the CDEP are discussed. C.R.

A81-18007 # **SPS transportation requirements - Economical and technical.** D. E. Koelle (Messerschmitt-Bölkow-Blohm GmbH, Ottobrunn, West Germany). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 6 p.

Economic feasibility of Satellite Power System (SPS) operations may best be achieved with a Single-Stage-To-Orbit (SSTC) launch vehicle to deliver the payload to low earth orbit and a ground-based chemical Orbital Transfer Vehicle (OTV) to lift it to geosynchronous orbit and back. An SSTO-OTV combination with a launch mass of 1280 Mg and a payload ratio of 2.3% would have a specific cost of 3.6 man-years per metric ton for 100 flights. A launch-vehicle fleet of as few as 2-3 reusable vehicles could accommodate a 6-year program with a 3-week turnaround, or a 3-year program with a 15-week turnaround, the payload in either case ranging from 200-300 Mg. The present rough estimate of 50 dollars to 150 dollars per kilogram to GEO makes it attractive for international funding and cooperation to avoid duplication and lost time. R.S.

A81-18008 # **The solar power satellite - Past, present and future.** P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 10 p. 5 refs.

The potential and the problems of solar energy are discussed, covering all aspects of the necessary technology and its economic and political consequences. The concept of the solar power satellite (SPS) is introduced, noting its feasibility through the space technology of the 1990's. Proposed objectives, including consideration of finite resources, environmentally benign operations and global benefits are covered, as are technical details on power transmission (microwave beams of the 2.50 GHz frequency or the laser beams at 10 MW), and on assembly in orbit through the space transportation system. From the point of view of economic possibilities, costs are estimated at between $1500 to $4000 per kW and finally, ecological and international topics are touched upon. N.D.

A81-18010 # **Some critical aspects of solar power satellite technology.** I. V. Franklin (British Aerospace, Dynamics Group, Bristol, England). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 5 p.

It is sometimes said that the SPS can be designed and built using an extension of existing and proven technologies. This is not quite true, and this paper seeks to identify those areas of technology which either need to be established and those areas which need extension, with an indication of the required scope. The paper does not intend to cover the whole field but rather to concentrate on some selected areas such as photovoltaic conversion which requires development leading to improved efficiency, low costs, high production rates and mass production methods for supplying finished fully integrated modules of solar array blankets. A second example concerns the development of large scale space structures and their behavior. The third area is concerned with the power transmission system, and what the requirements may be if Europe is to consider receiving SPS generated power. (Author)

A81-18013 # **SPS environmental effects on the upper atmosphere.** L. M. Duncan (California, University, Los Alamos, N. Mex.). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 9 p. 21 refs.

This paper reviews the ionospheric effects and associated environmental impacts which may be produced during the construction and operation of a solar power satellite system. Propellant emissions from heavy lift-launch vehicles are predicted to cause wide-spread ionospheric depletions in electron and ion densities. Collisional damping of the microwave power beam in the lower ionosphere can significantly enhance the local free electron temperatures. Thermal self-focusing of the power beam in the ionosphere may excite variations in the beam powerflux density and create large-scale field-aligned electron density irregularities. These large-scale irregularities may also trigger the formation of small-scale plasma striations. Ionospheric modifications can lead to the development of potentially serious telecommunications and climate impacts. A comprehensive research program is being conducted to understand the physical interactions driving these ionospheric effects and to determine the scope and magnitude of the associated environmental impacts. (Author)

A81-18014 # **Assessment of SPS photovoltaic solar array requirements.** J. Rath (Telefunken AG, Wedel, West Germany). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 7 p. 7 refs.

Performance and structural requirements for photovoltaic solar arrays which would ensure the technical and economic feasibility of SPS are discussed in relation to the current state of the art of solar array technology. Consideration is given to the requirements for technology availability, satellite lifetime, transmitted and received power, solar array dimensions and operating voltage, solar cell efficiency, dimensions and radiation resistance, and mass production and costs, and it is pointed out that several of the requirements, including solar cell area and thickness and array operating voltages, are already being addressed in current R&D programs. In the areas of solar cell efficiency and radiation resistance and elevated voltage solar array technology, however, it is shown that a concentrated development effort is necessary to meet program deadlines for technology availability by 1990. A.L.W.

A81-18016 # **About the S.P.S. transmitting antenna radiation pattern.** P. F. Combes (ONERA, Centre d'Etudes et de Recherches de Toulouse, Toulouse, France). *SUNSAT Energy Council and Centre National d'Etudes Spatiales, International Symposium on Solar Power Satellites, Toulouse, France, June 25-27, 1980, Paper.* 5 p.

In the present paper, the hypotheses underlying the calculation of the radiation pattern of the solar power satellite's (SPS) transmitting antenna are critically analyzed, and the factors which may affect the ideal design conditions are noted. A method for computing the 'actual' radiation pattern is proposed. V.P.

A81-18229 **A non-exclusive satellite power system.** J. E. Drummond (Power Conversion Technology, Inc., San Diego, Calif.) and P. F. Cowhey (California, University, La Jolla, Calif.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-10.* 13 p. 9 refs.

A modification of the satellite solar power system employing smaller satellites that are not stationary but move in circular or elliptical orbits of two or three hour periods is discussed. The orbits could be inclined at plus or minus 63.4 deg, 73.1 deg, or 14.3 deg to the equatorial plane. This Interregional or Isoinsolation Power System (IPS) greatly reduces the mass and cost of the antenna needed in the sky and the area required for the rectenna and safety region on the ground (the product of the areas of the antennas and rectennas of the IPS system being between 10 and 20 times lower than that required in the conventional SPS system). International control of IPS through a Solar Satellite Consortium (Solsat) is advocated, patterned after the successful Intelsat consortium, and it is stressed that the system must not be allowed to acquire a military capacity. It is emphasized that the smaller rectennas would not destabilize the ionosphere. C.R.

A81-18230 **Experimental compact space power station.** M. Pospisil, L. Pospisilova (Ceskoslovenska Akademie Ved, Astronomicky Ustav, Ondrejov, Czechoslovakia), Z. Hanzelka (Ceskoslovenska Vedecka-Technicka Spolecnost, Uherske Hradiste, Czechoslovakia), and M. Prochazka (Vyzkumny Ustav pro Sdelovaci Techniku, Prague, Czechoslovakia). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-12.* 17 p. 12 refs.

A hexagonal structure of 1-km diameter and a weight of 500 metric tons situated at geosynchronous orbit is proposed for testing a space power station of 64 MW peak power in operation and for evaluating materials, means and methods needed for production of large stations. In this compact space power station, solar blankets and microwave sources are situated on one supporting structure, thus saving a lot of auxiliary parts, but the exploitation of solar elements is 3.3 times lower than for an earlier concept. (Author)

A81-18231 **Space manufacturing in the construction of solar power satellites - Energy budget and cost calculation.** J. Ruth and W. Westphal (Berlin, Technische Universität, Berlin, West Germany). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-13.* 17 p. 18 refs.

The paper presents a model of a solar Satellite Power System (SPS) in which the overall system cost and the total energy investment of ground-based construction is compared to that of space-based construction. For the purpose of testing the model's validity, the investigation is restricted to the manufacture of the satellite's silicon solar-cell components, which, at 25796 x 1000 kg, comprise approximately 50% of the SPS mass. The model specifies a three-phase implementation of 120 satellites (5 GW each) over a 50-year period, and assumes a 10 year replacement span for the production machinery. All materials used are terrestrial. Although system costs are similar, the space-manufacturing option has a 21% 'efficiency advantage' over its alternative in terms of energy investment and return. R.S.

A81-18235 **Power generation from laser-produced plasma.** K. Kuriki and K. Akai (Tokyo, University, Tokyo, Japan). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-20.* 11 p. 5 refs.

Conversion of laser energy into electrical energy has been experimentally studied as a process subsequent to the power transmission from Solar Power Satellite to the earth or between space stations. In the scheme proposed here, the electrical power was generated by the charge separation at the expense of the kinetic energy of laser-produced plasma. (Author)

A81-18246 **A plan of experimental study in environmental impact by microwave power transmission.** N. Fugono and H. Mori (Ministry of Posts and Telecommunications, Radio Research Laboratories, Koganei, Tokyo, Japan). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-22.* 7 p.

An experimental system for the investigation of the effects of microwave transmissions from solar power satellites on the environment, particularly the ionosphere and neutral atmosphere, is proposed. In accordance with requirements that the experimental system resemble as closely as possible the operational characteristics of an actual system, the planned experimental system makes use of a phased array antenna of aperture 500 m transmitting at a frequency of 2.45 GHz at a power of 4 MW for 1 minute. The use of pulse code modulation would also enable backscattering measurements to be made of the effects of the transmission on the ionosphere, as well as ionospheric and neutral atmosphere sounding. Results of the proposed experiment are thus expected to contribute to solar power satellite design as well as the earth environmental observation, radio astronomy and the development of very long distance communication systems. A.L.W.

A81-18237 **Numerical estimation of SPS microwave impact on ionospheric environment.** H. Matsumoto (Kyoto University, Uji, Japan). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-23.* 9 p. 8 refs.

A possible interaction with the ionosphere of an intense microwave which will be used in energy transmission from Solar Power Satellite (SPS) to the earth, is numerically studied. Microwave heating of the ionosphere and nonlinear excitation of electron plasma waves and ion acoustic waves are numerically studied for a model ionosphere. (Author)

A81-18636 # **A global solar power satellite system.** P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.). *American Society of Mechanical Engineers, Century 2 AeroSpace Conference, San Francisco, Calif., Aug. 13-15, 1980, Paper 80-C2/Aero-6.* 8 p. 29 refs. Members, $1.50; nonmembers, $3.00.

A survey is presented of the potential of solar energy satellites for global needs including production of solar energy in space for applications on earth. The solar power satellite (SPS) system is compared with terrestrial solar energy methods, noting that the power generated by SPS can be transmitted to earth by microwave or laser beams. The space transportation system, orbital assembly and maintenance, and the SPS/utility power pool interface are discussed; the economic considerations of SPS based on a classical risk/decision analysis, the environmental impact, and the legal questions relating to possible accidents are examined. A.T.

A81-20686 # **Environmental assessment for the satellite power system concept development and evaluation program.** M. M. Abromavage (Illinois Institute of Technology, Chicago, Ill.) and A. R. Valentino (Argonne National Laboratory, Argonne, Ill.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 19th, St. Louis, Mo., Jan. 12-15, 1981, Paper 81-0244.* 9 p. 8 refs. Research supported by the U.S. Department of Energy.

A 3-year environmental assessment of the satellite power system energy concept has been completed. Potential environmental effects and candidate mitigating strategies have been identified. The important effects which depend upon satellite and energy transmission design are: Low-level long-term microwave exposure to the public; ionizing radiation exposure to workers in space; space transportation exhaust effluent effects in the atmosphere; and electromagnetic compatibility impacts at geostationary earth orbit locations, in the ionosphere, and on earth. These potential effects would influence any further development of the satellite energy concept, including design preferences, energy transmission principles, and system construction, operating and maintenance scenarios. (Author)

A81-22648 **Preliminary environmental assessment for the satellite power system /SPS/.** *Journal of Environmental Sciences*, vol. 24, Jan.-Feb. 1981, p. 16-22, 31, 32.

The collection of solar energy via SPS for conversion to microwave energy and subsequent conversion to electricity is examined in light of potential health hazards, effect on ecosystems, and interaction of electromagnetic systems. Research exploring the immunologic, teratologic, and behavioral effects of a frequency of 2.45 gigahertz is discussed. Tropospheric effects of rocket effluents are documented in terms of the modification of weather conditions. Rectenna waste heat may result in alterations in the chemical composition of the stratosphere and mesosphere affecting ozone concentrations. Microwave energy transmitted might be sufficient to heat the ionosphere resulting in increased electron temperatures, irregularities in electron densities, focusing of electromagnetic waves and absorption or scattering of radio waves. Principal nonmicrowave effects catalogued are pollution and exposure of the general public and space workers to explosives and toxins. L.S.

A81-23724 **Solar satellites - The trillion dollar question.** J. K. Beatty. *Science 80*, vol. 1, Dec. 1980, p. 28-33.

The obstacles facing the solar power satellite system (SPS) are discussed with a view toward the NASA-DOE reference system. The problems identified include the research and environmental issues surrounding the transmission of microwave energy from orbit to the system rectennas and the cost factor. The cost optimistically aims at one trillion dollars for the total, 60 satellite system. The cost per installed kilowatt may fall anywhere from 3100 up to 16,000 dollars. L.S.

A81-23861 **Energy from space - A survey of activities for power generation using space technology.** D. Kassing and G. Seibert (ESA, Paris, France). *Advances in Earth Oriented Applications of Space Technology*, vol. 1, no. 1, 1981, p. 19-31. 17 refs.

A comprehensive review is presented of solar satellite power systems' conceptual development over the last decade, their current status, possible development schedule, economic viability, and social and environmental impacts. It is suggested that further development and testing of selected system elements may supply the key to greater economy and more rapid implementation. O.C.

A81-24830 * **Laser-SPS systems analysis and environmental impact assessment.** R. E. Beverly, III. *Space Solar Power Review*, vol. 1, no. 4, 1980, p. 317-344. 61 refs. Contract No. NAS8-32475.

The systems feasibility and environmental impact of replacing the microwave transmitters on the Satellite Power System with laser transmitters are examined. The lasers suggested are two molecular-gas electric-discharge lasers (EDL's), namely the CO and CO2 lasers. Calculations are made on system efficiency, atmospheric transmission efficiency, and laser beam spreading. It is found that the present satellite concept using lasers is far too inefficient and massive to be economically viable. However, the safety issues associated with laser power transmission appear tractable, and no effects could be identified which present a real danger of serious injury to the environment, although certain phenomena deserve closer scrutiny. D.K.

A81-24831 * **SPS design with solid-state transmitter.** M. Ettenberg (RCA David Sarnoff Research Center, Princeton, N.J.). *Space Solar Power Review*, vol. 1, no. 4, 1980, p. 345-349. Contract No. NAS9-15755.

The replacement of the klystrons in the microwave transmitter in the SPS leads to major redesign considerations. Several curves are presented which show the interrelations of the major design features, the power level and the transmitting and receiving dimensions. (Author)

A81-24832 **Workshop on the microwave power transmission system for the solar power satellite - Review panel report.** J. W. Freeman and W. L. Wilson (Rice University, Houston, Tex.). *Space Solar Power Review*, vol. 1, no. 4, 1980, p. 361-371.

A81-24833 **Recent developments in the space transportation system for the solar power satellite.** H. P. Davis. *Space Solar Power Review*, vol. 1, no. 4, 1980, p. 375-381.

The report summarizes the space transportation presentations made at the 1980 Lincoln, Nebraska, SPS (Solar Power Satellite) Program Review Conference. Emphasis was on the highest cost element of the system, the HLLV (launch vehicle), requiring more than 80% of the total investment phase transportation funding. The cost savings of developing a much smaller HLLV (100 tons payload class) are discussed. Other topics discussed include the European Space Agency space transportation system and the reduction of costs by using a near-equatorial launch site, the VTOHL reference system, the use of electrical propulsion, a sea platform HLLV launch and recovery facility and the NASA-JPL magnetoplasmadynamic arcjet thruster. Questions of environmental impact are also discussed and found to be negligible. D.K.

N81-10231# **National Telecommunication Information Administration, Boulder, Colo. Inst. for Telecommunication Sciences.**

IMPACT OF SATELLITE POWER SYSTEM (SPS) HEATING ON VLF, LF, AND MF TELECOMMUNICATIONS SYSTEMS ASCERTAINED BY EXPERIMENTAL MEANS

C. M. Rush, E. J. Violette, R. H. Espeland, J. C. Carroll, and K. C. Allen Apr. 1980 105 p refs
(PB80-194459; NTIA-R-80-37) Avail: NTIS HC A06/MF A01

Using the high-power high-frequency transmitter facility loecated at Platteville, Colorado, power densities comparable to the Satellite Power System (SPS) can be delivered to the heights of 70 to 100 km above the surface of the earth. Observations of the performance of telecommunication systems that operate in the VLF, LF, and MF portions of the spectrum were investigated during times when the ionosphere was modified with SPS comparable power density and when it was not. The results obtained indicate that the SPS, as currently configured with a peak power density of 23 mW/sq cm, will not adversely impact upon the performance of VLF, LF, and MF telecommunicaiton systems. GRA

N81-10238*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

PILOT SIGNALS FOR LARGE ACTIVE RETRO-DIRECTIVE ARRAYS

C. H. Chen Aug. 1980 19 p refs
(NASA-TM-78310) Avail: NTIS HC A02/MF A01 CSCL 17B

It has been suggested that for large active retrodirective arrays, as in the solar power system, a two tone uplink pilot signal with frequencies symmetrically situated around the downlink frequency be used in order to reduce ionospheric biases and to lower the cost since a two tone receiver is economically much cheaper than a single tone phase locked receiver. Such a system now faces two difficulties: the Pi-ambiguity; and a large phase difference between the downlink and uplink signals. The Pi-ambiguity is shown to be easily removed by using a two tone uplink signal with both frequencies situated at one side of the downlink frequency, and the phase difference can be greatly reduced with a three tone or a four tone uplink pilot signal. R.K.G.

N81-10295# Directorate of Radio Technology, London (England).

THE INTERACTIONS OF A SOLAR POWER SATELLITE TRANSMISSION WITH THE IONOSPHERE AND TROPOSPHERE

K. A. Hughes *In* AGARD Propagation Effects in Space/Earth Paths Aug. 1980 7 p refs

Avail: NTIS HC A22/MF A01

In a system of solar power satellites, (SPS), solar energy is collected by a large array of solar cells in geostationary orbit, converted to rf power at microwave frequencies and beamed to Earth for conversion into dc. The propagation of the high power microwave beam through the Earth's atmosphere initiates interactions in the ionosphere and troposphere that have disruptive effects on existing radio services. In addition, the transmission of the SPS beam is also affected. Radio interference on the SPS frequency occurs from scattering of the beam in both the ionosphere and troposphere; more serious broad-band interference may arise from ionospheric modification, resulting from intense ohmic heating. The problems associated with these interactions are discussed and the effects on existing radio services are quantified. S.F.

N81-10296# AEG-Telefunken, Bonn (West Germany).

ON MICROWAVE POWER TRANSMISSION AND THE FEASIBILITY OF POWER SATELLITES FOR EUROPE

Diederich Koehn *In* AGARD Propagation Effects in Space/Earth Paths Aug. 1980 6 p refs

Avail: NTIS HC A22/MF A01

Considerations of giant power plants in remote areas (because of the environmental contamination) or in space suggest or even force a noncable bound transmission of power, e.g., by a collimated microwave beam. However, the propagation of microwaves is affected by tropospheric and ionospheric effects (attenuation, diffraction, reflection, decollimation, depolarization) which degrade the power transmission efficiency. Power satellite concepts are discussed and the principles of the proposed microwave power transmission system are explained. The main interfering atmospheric effects are explained and an appraisal of their influence on the transmission path and the overall power transmission system is given. Some of those effects show a latitudinal dependence, and conclusions on the feasibility of power satellite systems for Europe are derived. S.F.

N81-10297# Institute for Telecommunication Sciences, Boulder, Colo.

POTENTIAL IMPACT OF THE SATELLITE POWER SYSTEM ON COMMUNICATION AND ELECTRONIC SYSTEMS AND THE IONOSPHERE

W. B. Grant, C. M. Rush, and E. L. Morrison *In* AGARD Propagation Effects in Space/Earth Paths Aug. 1980 19 p ref
Avail: NTIS HC A22/MF A01

The impact of the operation of the satellite power system upon the ionosphere and telecommunication systems is described. Analysis of possible functional and operational degradation of electromagnetic systems (communication systems, radars, navigation aids, satellites) and environment sensitive instruments and systems (computers, sensors, electronic medical instruments and security devices) due to direct SPS power coupling are studied in detail. Development of mitigating techniques when unacceptable degradation is discovered in a given equipment or system is described. Assessment of possible impacts upon telecommunication systems and implications for electromagnetic compatibility are discussed. The degree to which the ionosphere will be modified by the passage of the microwave power beam and what impact this modification has upon telecommunication systems are discussed. Theoretical efforts to simulate SPS operational impacts are described. S.F.

N81-10526*# Rice Univ., Houston, Tex.

ELECTROSTATIC PROTECTION OF THE SOLAR POWER SATELLITE AND RECTENNA. PART 2: LIGHTNING PROTECTION OF THE RECTENNA Final Report

Washington NASA Nov. 1980 124 p
(Contract NAS8-33023)
(NASA-CR-3345) Avail: NTIS HC A06/MF A01 CSCL 22B

Computer simulations and laboratory tests were used to evaluate the hazard posed by ligtning flashes to ground on the Solar Power Satellite rectenna and to make recommendations on a lightning protection system for the rectenna. The distribution of lightning over the lower 48 of the continental United States was determined, as were the interactions of lightning with the rectenna and the modes in which those interactions could damage the rectenna. Lightning protection was both required and feasible. Several systems of lightning protection were considered and evaluated. These included two systems that employed lightning rods of different lengths and placed on top of the rectenna's billboards and a third, distribution companies; it consists of short lightning rods all along the length of each billboard that are connected by a horizontal wire above the billboard. The distributed lightning protection system afforded greater protection than the other systems considered and was easier to integrate into the roctenna's structural design. T.U.

N81-10527*# Rockwell International Corp., Columbus, Ohio.

SATELLITE POWER SYSTEMS (SPS) LASER STUDIES. VOLUME 1: LASER ENVIRONMENTAL IMPACT STUDY Final Report, Oct. 1978 - Mar 1979

R. E. Beverly, III Washington Nov. 1980 87 p refs
(Contract NAS8-32475)
(NASA-CR-3346; SSD-80-0119-1) Avail: NTIS HC A05/MF A01 CSCL 10A

The environmental impact of space to Earth power transmission using space borne laser subsystems is emphasized. A laser system is defined, estimates of relevant efficiencies for laser power generation and atmospheric transmission are developed, and a comparison is made to a microwave system. Ancillary issues, such as laser beam spreading, safety and security, mass and volume estimates and technology growth are considered. R.K.G.

10 SOLAR POWER SATELLITE SYSTEM

N81-11466*# ECON, Inc., Princeton, N. J.
SATELLITE POWER SYSTEM SALVAGE AND DISPOSAL ALTERNATIVES Final Report
Nov. 1980 91 p refs
(Contract NAS8-33783)
(NASA-CR-3349; ECON-80-148-1) Avail: NTIS HC A05/MF A01 CSCL 10A

A wide range of salvage options for the SPS satellite, ranging from use in and beyond geosynchronous orbit to use in low Earth orbit in return and use on Earth are presented. The satellite can be used intact to provide power for various purposes, it can be cannibalized or it can be melted down to supply materials for space or ground based products. The use of SPS beyond its nominal lifetime provides value that can be deducted from the SPS capital investment cost. The present value of the salvage value of the SPS satellites, referenced to the system initial operation data, is on the order of five to ten percent of its on-orbit capital cost. (Given a 30 year satellite lifetime and a four percent discount rate, the theoretical maximum salvage value is 30.8 percent of the capital cost.) The SPS demonstration satellite is available some 30 years earlier than the first full scale SPS satellite and has a salvage value on the order of 80 percent of its on-orbit capital cost. In the event that it becomes desirable to dispose of either the demonstration of full scale SPS satellite, a number of disposal options is presented for which intact disposal costs are less than one percent of capital costs.
T.M.

N81-11468*# Raytheon Co., Wayland, Mass. Equipment Div.
SOLID STATE SPS MICROWAVE GENERATION AND TRANSMISSION STUDY. VOLUME 1: PHASE 2 Final Report
Owen E. Maynard Washington Nov. 1980 236 p refs
(Contract NAS8-33157)
(NASA-CR-3338; M-311; ER80-4074-1) Avail: NTIS HC A11/MF A01 CSCL 10A

The solid state sandwich concept for Solar Power Station (SPS) was investigated. The design effort concentrated on the spacetenna, but did include some system analysis for parametric comparison reasons. The study specifically included definition and math modeling of basic solid state microwave devices, an initial conceptual subsystems and system design, sidelobe control and system selection, an assessment of selected system concept and parametric solid state microwave power transmission system data relevant to the SPS concept. Although device efficiency was not a goal, the sensitivities to design of this efficiency were parametrically treated. Sidelobe control consisted of various single step tapers, multistep tapers, and Gaussian tapers. A preliminary assessment of a hybrid concept using tubes and solid state is also included. There is a considerable amount of thermal analysis provided with emphasis on sensitivities to waste heat radiator form factor, emissivity, absorptivity, amplifier efficiency, material and junction temperature.
Author

N81-11469*# Rice Univ., Houston, Tex.
ELECTROSTATIC PROTECTION OF THE SOLAR POWER SATELLITE AND RECTENNA. PART 1: PROTECTION OF THE SOLAR POWER SATELLITE Final Report
Washington NASA Nov. 1980 36 p refs
(Contract NAS8-33023)
(NASA-CR-3344; M-308) Avail: NTIS HC A03/MF A01 CSCL 10A

Several features of the interactions of the Solar Power Satellite (SPS) with its space environment are examined theoretically. The voltages produced at various surfaces due to space plasmas and the plasma leakage currents through the kapton and sapphire solar cell blankets are calculated. At geosynchronous orbit, this parasitic power loss is only 0.7%, and is easily compensated by oversizing. At low Earth orbit, the power loss is potentially much larger (3%), and anomalous arcing is expected for the EOTV high voltage negative surfaces. Preliminary results of a three dimensional self consistent plasma and electric field computer program are presented, confirming the validity of the predictions made from the one dimensional models. Lastly, magnetic shielding of the satellite is considered to reduce the power drain and to protect the solar cells from energetic electron and plasma ion bombardment. It is concluded that minor modifications can allow the SPS to operate safely and efficiently in its space environment. Subsequent design changes will substantially alter the basic conclusions.
L.F.M.

N81-11981*# Alabama Univ. at Huntsville. Dept. of Physics.
PILOT SIGNALS FOR LARGE ACTIVE RETRODIRECTIVE ARRAYS
C. H. Chan *In its* Res. Rept.: The 1980 NASA/ASEE Summer Fac. Fellowship Program Oct. 1980 17 p refs

(Grant NGT-01-002-099)
Avail: NTIS HC A99/MF A01 CSCL 20N

It was suggested that for large active retrodirective arrays, as in the solar power system, a two tone uplink pilot signal with frequencies symmetrically situated around the downlink frequency be used in order to reduce ionospheric biases and to lower the cost. Unfortunately such a system faces the following difficulties: (1) the pi-ambiguity, and (2) a large phase difference between the downlink and uplink signals. It is shown how the pi-ambiguity can be easily removed by using a two tone uplink signal with both frequencies situated at one side of the downlink frequency, and the phase difference can be greatly reduced with a three tone or a four tone uplink pilot signal.
E.D.K.

N81-12153# Royal Aircraft Establishment, Farnborough (England).
SOLAR POWER SATELLITES. A REVIEW OF THE SPACE TRANSPORTATION OPTIONS
D. G. Fearn London HMSO Mar. 1980 194 p refs
(RAE-TR-80034; RAE-Space-577; BR74953) Avail: NTIS HC A09/MF A01

The options available for lifting both heavy payloads and personnel to low Earth orbit, and from there to geostationary orbit are reviewed. It is concluded that conventional launcher technology using liquid hydrogen/liquid oxygen engines should be adequate for the former task. The latter can best be accomplished using electric propulsion with ion thrusters being the most suitable devices, owing to their high efficiency and advanced state of development. Environmental effects of such a transportation system are considered and it is concluded that they should be acceptable.
Author (ESA)

N81-12943*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SATELLITE POWER SYSTEM CONCEPT DEVELOPMENT AND EVALUATION PROGRAM. VOLUME 1: TECHNICAL ASSESSMENT SUMMARY REPORT
Nov. 1980 116 p refs
(NASA-TM-58232) Avail: NTIS HC A06/MF A01 CSCL 10A

Candidate satellite power system (SPS) concepts were identified and evaluated in terms of technical and cost factors. A number of alternative technically feasible approaches and system concepts were investigated. A reference system was defined to facilitate economic, environmental, and societal assessments by the Department of Energy. All elements of the reference system were defined including the satellite and all its subsystems, the orbital construction and maintenance bases, all elements of the space transportation system, the ground receiving station, and the associated industrial facilities for manufacturing the required hardware. The reference conclusions and remaining issues are stated for the following topical areas: system definition; energy conversion and power management; power transmission and reception; structures, controls, and materials; construction and operations; and space transportation.
R.C.T.

N81-12966*# Rice Univ., Houston, Tex.
SOLAR POWER SATELLITE OFFSHORE RECTENNA STUDY Final Report
Nov. 1980 252 p refs Prepared in cooperation with Brown and Root Development, Inc. and Arthur D. Little, Inc.
(Contract NAS8-33023)
(NASA-CR-3348) Avail: NTIS HC A12/MF A01 CSCL 10A

It was found that an offshore rectenna is feasible and cost competitive with land rectennas but that the type of rectenna which is suitable for offshore use is quite different from that specified in the present reference system. The result is a nonground plane design which minimizes the weight and greatly reduces the number of costly support towers. This preferred design is an antenna array consisting of individually encapsulated dipoles with reflectors supported on feed wires. Such a 5 GW rectenna could be built at a 50 m water depth site to withstand hurricane and icing conditions for a one time cost of 5.7 billion dollars. Subsequent units would be about 1/3 less expensive. The east coast site chosen for this study represents an extreme case of severe environmental conditions. More benign and more shallow water sites would result in lower costs. Secondary uses such as mariculture appear practical with only minor impact on the rectenna design. The potential advantages of an offshore rectenna, such as no land requirements, removal of microwave radiation from populated areas and minimal impact on the local geopolitics argue strongly that further investigation of the offshore rectenna should be vigorously pursued. Author

N81-12980*# Rockwell International Corp., Columbus, Ohio. Space Operations and Satellite Systems Div.
SATELLITE POWER SYSTEM (SPS) LASER STUDIES. VOLUME 2: METEOROLOGICAL EFFECTS ON LASER BEAM PROPAGATION AND DIRECT SOLAR PUMPED LASERS FOR THE SPS Final Report
R. E. Beverly, III Columbus, Ohio NASA Nov. 1980 143 p refs
(Contract NAS8-32475)
(NASA-CR-3347; SSD-80-0119-2-Vol-2) Avail: NTIS HC A07/MF A01 CSCL 10A

The primary emphasis of this research activity was to investigate the effect of the environment on laser power transmission/reception from space to ground. Potential mitigation techniques to minimize the environment effect by a judicious choice of laser operating parameters was investigated. Using these techniques, the availability of power at selected sites was determined using statistical meteorological data for each site. Author

N81-12982# Argonne National Lab., Ill. Energy and Environmental Systems Div.
LASER SATELLITE POWER SYSTEMS
E. W. Walbridge Jan. 1980 84 p refs
(Contract W-31-109-eng-38)
(ANL/ES-92) Avail: NTIS HC A05/MF A01

A laser satellite power system (SPS) converts solar power captured by Earth-orbiting satellites into electrical power on the Earth's surface, the satellite-to-ground transmission of power being effected by laser beam. The system has four important advantages over a microwave system: land requirements are much less, radiation levels are low outside the laser ground stations, laser beam sidelobes are not expected to interfere with electromagnetic systems, and the laser system lends itself to small-scale demonstration. After describing lasers and how they work, the five lasers that are candidates for application in a laser SPS: electric discharge lasers, direct and indirect solar pumped lasers, free electron lasers, and closed-cycle chemical lasers are discussed. DOE

N81-12986# Environmental Resources Group, Los Angeles, Calif.
PROTOTYPE ENVIRONMENTAL ASSESSMENT OF THE IMPACTS OF SITING AND CONSTRUCTING A SATELLITE POWER SYSTEM (SPS)
Aug. 1980 272 p refs
(Contract W-31-109-eng-38)
(DOE/ER-0072) Avail: NTIS HC A12/MF A01

The study objectives were: (1) to develop a comprehensive prototype assessment of the nonmicrowave related impacts on the natural and human environments of the reference system SPS GRS; (2) to assess the impacts of GRS construction and operations in the context of actual baseline data for a site in the California desert which, while it has not been selected as eligible for GRS siting, has many features that are optimal for SPS; and (3) to identify critical GRS characteristics or parameters that are most significant in terms of both the natural and human environment. Critical project parameters revealed include: the sheer size and intensity of use of the contiguous land area required by an SPS GRS; the lack of flexibility in siting individual rectenna structures once the rectenna boundaries are established; the difficulties in finding suitable sites that do not conflict with other societal needs and values; uncertainties relating to reestablishing native ecosystems following total ecosystem modification during construction, and the related need for further research into microclimatic effects near the ground surface beneath the rectenna panels. DOE

N81-13469*# Raytheon Co., Wayland, Mass. Advanced Development Lab.
SOLID STATE SPS MICROWAVE GENERATION AND TRANSMISSION STUDY. VOLUME 2, PHASE 2: APPENDICES Final Report
Owen E. Maynard Washington NASA Nov. 1980 115 p refs
(Contract NAS8-33157)
(NASA-CR-3339; ER80-4074-2) Avail: NTIS HC A06/MF A01 CSCL 10A

The solid state sandwich concept for SPS was further defined. The design effort concentrated on the spacetenna, but did include some system analysis for parametric comparison reasons. Basic solid state microwave devices were defined and modeled. An initial conceptual subsystems and system design was performed as well as sidelobe control and system selection. The selected system concept and parametric solid state microwave power transmission system data were assessed relevant to the SPS concept. Although device efficiency was not a goal, the sensitivities to design of this efficiency were parametrically treated. Sidelobe control consisted of various single step tapers, multistep tapers and Gaussian tapers. A hybrid concept using tubes and solid state was evaluated. Thermal analyses are included with emphasis on sensitivities to waste heat radiator form factor, emissivity, absorptivity, amplifier efficiency, material and junction temperature. A.R.H.

N81-13640# Argonne National Lab., Ill.
ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS) CONCEPT DEVELOPMENT AND EVALUATION PROGRAM (CDEP)
Anthony R. Valentino Aug. 1980 128 p refs
(Contract W-31-109-eng-38)
(DOE/ER-0069) Avail: NTIS HC A07/MF A01

In the satellite power system (SPS), satellite in geosynchronous Earth orbit would collect solar energy in space, convert it to microwaves, and transmit the microwaves to receiving antennas (rectennas) on earth. At the rectennas, the microwave energy would be converted to electricity. This SPS environmental assessment considers the microwave and nonmicrowave effects on the terrestrial environmental and human health, atmospheric effects, and effects on electromagnetic systems. No environmental problem was identified that would preclude the continued study of SPS technology. To increase the certainty of the assessment, some research was initiated and long-term research is being planned. DOE

N81-14392*# Tennessee Univ., Knoxville. Systems and Radar Lab.
SATELLITE POWER SYSTEM (SPS) ANTENNA POINTING CONTROL Final Report
Washington, D.C. Nov. 1980 86 p refs
(Contract NAS8-33604)
(NASA-CR-3350; M-317) Avail: NTIS HC A05/MF A01 CSCL 10A

Accuracy requirements for the SPS antenna pointing control consists of a mechanical pointing accuracy of three arc minutes and an electronic phased array pointing accuracy of three arc seconds. Results of this study, based on the factors considered in current analysis, show that the three arc minute overall pointing control accuracy can be achieved for the SPS in practice. E.D.K.

N81-14396*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL AND DYNAMICS STUDY FOR THE SATELLITE POWER SYSTEM. VOLUME 1: MPTS/SPS COLLECTOR DYNAMIC ANALYSIS AND SURFACE DEFORMATION
S. J. Wang 1 Sep. 1980 113 p refs Prepared for JPL
(Contract NAS7-100)
(NASA-CR-163826; JPL-Pub-80-77-Vol-1) Avail: NTIS HC A06/MF A01 CSCL 10A

The basic dynamic properties and performance characteristics of the microwave power transmission satellite antenna were analyzed in an effort to develop criteria, requirements, and constraints for the control and structure design. The vibrational properties, the surface deformation, and the corresponding scan loss under the influence of disturbances are considered. A.R.H.

N81-14470# Systems Control, Inc., Palo Alto, Calif.
SATELLITE POWER SYSTEM: UTILITY IMPACT STUDY Final Report
J. G. Bohn, J. W. Patmore, and H. W. Zaininger Sep. 1980 70 p refs Sponsored by Electric Power Research Inst.
(EPRI-AP-1548; TPS-79-752) Avail: NTIS HC A04/MF A01

The reference system design would utilize 60 satellites in geosynchronous orbits. Each satellite would collect solar energy and convert it to electricity by means of a 55 sq km array of photovoltaic cells. This dc electricity would then be converted to microwave and transmitted to a 130 sq km receiving antenna on the ground, where it would be reconverted to dc and then ac electricity before being fed into the conventional utility power system. Each satellite would deliver approximately 5 GW of power at the utility interface. It is estimated that each 5 GW satellite and ground receiving antenna plus associated equipment would cost $10 to 20 billion (1977 dollars), with the entire 60 satellite system costing $800 billion to 1.2 trillion. This amounts to $2000 to 4000 per kW. Although there are serious technical problems to be solved befor the SPS would be feasible, the cost of the system may be the greatest obstacle to its implementation. DOE

N81-14481*# Alabama Univ. in Huntsville. Environmental and Energy Center.
SPS ENERGY CONVERSION POWER MANAGEMENT WORKSHOP Final Report
Jun. 1980 98 p Workshop held in Huntsville, Ala., 5-7 Feb. 1980
(Contracts NAS8-33132; DE-AS01-78CS-34218)
(NASA-CR-163840; DOE/CS-34218/T1) Avail: NTIS HC A05/MF A01 CSCL 10A

Energy technology concerning photovoltaic conversion, solar thermal conversion systems, and electrical power distribution processing is discussed. The manufacturing processes involving solar cells and solar array production are summarized. Resource issues concerning gallium arsenides and silicon alternatives are reported. Collector structures for solar construction are described and estimates in their service life, failure rates, and capabilities are presented. Theories of advanced thermal power cycles are summarized. Power distribution system configurations and processing components are presented. T.M.

N81-14507# Institute for Telecommunication Sciences and Aeronomy, Boulder, Colo.
ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM. CONCEPT DEVELOPMENT AND EVALUATION PROGRAM: EFFECTS OF IONOSPHERIC HEATING ON TELECOMMUNICATIONS
Aug. 1980 97 p refs
(Contract DE-AI02-79CH-10003)
(DOE/ER-10003/T2) Avail: NTIS HC A05/MF A01 CSCL 13B

A program of national scope involving Government laboratories, industrial resources, and university personnel, was formulated. The effect of SPS operation upon the ionosphere was simulated by use of existing ground-based high-power transmitter facilities and the necessary formulations to permit the extrapolation of the simulations to the SPS operational scenario were developed. The programs of research and exploratory development undertaken for this assessment were grouped into three categories: simulation of telecommunication impacts, experimental studies of the physics of heating the ionosphere by radio waves, and theoretical studies. Author

N81-14508*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ENVIRONMENTAL IMPACTS OF THE SATELLITE POWER SYSTEM (SPS) ON THE MIDDLE ATMOSPHERE
Oct. 1980 39 p refs
(Contract DE-AI01-79ER-10035)
(NASA-TM-82228; DOE/ER-10035/01) Avail: NTIS HC A03/MF A01 CSCL 13B

The heavy lift launch vehicles (HLLV) proposed for use in constructing satellite power systems (SPS) would deposit various contaminants in the middle atmosphere, contaminants that would conceivable have adverse effects on climate and upper air structure. These contaminants consist of the major constituents of water vapor, hydrogen, carbon dioxide, and carbon monoxide, and the minor constituents of sulfur dioxide and nitric oxide in the rocket effluent, as well as nitric oxide formed during reentry. To assess the magnitudes of the effects, new models or modified existing models were constructed. Author

N81-18530*# National Aeronautics and Space Administration, Washington, D. C.
SOLAR POWER SATELLITE SYSTEM Patent Application
George L. Server, III, inventor (to NASA) (MIT, Cambridge) Filed 29 Sep. 1980 11 p Sponsored by NASA
(NASA-Case-HQN-10949-1; US-Patent-Appl-SN-191747) Avail: NTIS HC A02/MF A01 CSCL 10A

A solar power satellite system is provided which includes a power satellite and at least one reflector satellite. The power satellite, which constitutes the great mass of the system, has a geosynchronous, gravity gradient stabilized orbit. The power satellite comprises a planar array of solar cells, with the plane of the satellite being oriented so as to be parallel with the plane of its orbit. An antenna or antennas mounted on the power satellite are powered by the solar cells and serve to transmit microwave energy back to earth. The shape and orbit of the reflector satellite are controlled so that solar radiation is focused by the reflector satellite onto the solar array of the power satellite. NASA

N81-18533*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SOLAR POWER SATELLITE MICROWAVE TRANSMISSION AND RECEPTION
R. H. Dietz Dec. 1980 271 p refs Workshop held in Houston, Tex., 15-18 Jan. 1980
(NASA-CP-2141; S-503) Avail: NTIS HC A12/MF A01 CSCL 10A

Numerous analytical and experimental investigations related to SPS microwave power transmission and reception are reported. Aspects discussed include system performance, phase control, power amplifiers, radiating elements, rectenna, solid state configurations, and planned program activities.

N81-18534*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEM PERFORMANCE CONCLUSIONS
G. D. Arndt *In its* Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 7-17

Avail: NTIS HC A12/MF A01 CSCL 10A

The advantages and disadvantages of reducing power levels and using antennas with diameters smaller than 1 Km were evaluated if rectenna costs and land usage requirements become major factors, operating at 5800 megahertz should be considered. Three sequences (random, incoherent phasing, and concentric rings - center to edge) provided satisfactory performance in that the resultant sidelobe levels during startup/ shutdown were lower than the steady-state levels present during normal operations. Grating lobe peaks and scattered power levels were used to determine the array/subarray mechanical alignment requirements. The antenna alignment requirement is 1 min or 3 min depending on phase control configuration. System error parameters were defined to minimize scattered microwave power. A.R.H.

N81-10535*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE MICROWAVE POWER TRANSMISSION SYSTEM DESCRIPTION EXECUTIVE SUMMARY
Gordon R. Woodcock *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 19-27
Avail: NTIS HC A16/MF A01 CSCL 10A

The history of the concept of microwave power beaming to Earth is reviewed with emphasis on transmission frequency selection. Constraints on the system power level results from (1) required rejection of waste heat resulting from inefficiencies in the power conversion of dc electric power to microwave power; (2) the rf power intensity in the ionosphere; and (3) the effect of sidelobe level on aperture illumination factors. Transmitter arrangement, the power distribution system, attitude control, subarrays, waveguides, and alignment are discussed. A.R.H.

N81-10536*# Raytheon Co., Lexington, Mass.
INITIAL MPTS STUDY RESULTS: DESIGN CONSIDERATIONS AND ISSUES
Owen E. Maynard *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 28-32
Avail: NTIS HC A16/MF A01 CSCL 10A

One of the key issues identified during investigations of microwave power transmission systems from 1965 to 1976 was the need to assure that the billions of diodes on ground-based rectennas are sufficiently reliable to support long life times of approximately 30 years. Major systems studies conducted focused on waveguides; radio frequency interference and biological considerations; the relationship between performance, weight, and cost; risk assessment; crossed field directional amplifier noise; a 48 kW klystron; effects of the environment on propagation and phase control; rectenna technology; a rationale for the ground power density region; alternate technologies for orbital assembly; ionospheric effects and phase control; and reception conversion (rf to dc collector/converter). A.R.H.

N81-10537*# Boeing Aerospace Co., Seattle, Wash.
SPS LARGE ARRAY SIMULATION
S. Rathjen, B. R. Sperber, and E. J. Nalos *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 33-42

Avail: NTIS HC A16/MF A01 CSCL 10A

Three types of computer simulations were developed to study the SPS microwave power transmission system (MPTS). The radially symmetric array simulation is low cost and is utilized to investigate general overall characteristics of the spacetenna at the array level only. 'Tiltmain', a subarray level simulation program, is used to study the effects of system errors which modify the far-field pattern. The most recently designed program, 'Modmain,' takes the detail of simulation down to the RF module level and so to date is the closest numerical model of the reference design. A.R.H.

N81-10538*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ACHIEVABLE FLATNESS IN A LARGE MICROWAVE POWER TRANSMITTING ANTENNA
R. C. Ried *In its* Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 43-45 ref

Avail: NTIS HC A16/MF A01 CSCL 10A

A dual reference SPS system with pseudoisotropic graphite composite as a representative dimensionally stable composite was studied. The loads, accelerations, thermal environments, temperatures and distortions were calculated for a variety of operational SPS conditions along with statistical considerations of material properties, manufacturing tolerances, measurement accuracy and the resulting loss of sight (LOS) and local slope distributions. A LOS error and a subarray rms slope error of two arc minutes can be achieved with a passive system. Results show that existing materials measurement, manufacturing, assembly and alignment techniques can be used to build the microwave power transmission system antenna structure. Manufacturing tolerance can be critical to rms slope error. The slope error budget can be met with a passive system. Structural joints without free play are essential in the assembly of the large truss structure. Variations in material properties, particularly for coefficient of thermal expansion from part to part, is more significant than actual value. A.R.H.

N81-10540*# Emmanuel Coll., Boston, Mass.
PROPOSED EXPERIMENTAL STUDIES FOR ASSESSING IONOSPHERIC PERTURBATIONS ON SPS UPLINKING PILOT BEAM SIGNAL
Santimay Basu and Sunanda Basu *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 63-78 refs

(Contract F19628-78-C-0005; Grant NSF ATM-78-25264)
Avail: NTIS HC A16/MF A01 CSCL 10A

Evidence is presented for the occurrence of natural irregularities at midlatitude based on scintillation measurements by the use of VHF and GHz transmission from geostationary satellites, and from satellite in-situ measurements. An effort to determine the phase and intensity scintillation effects during ionospheric heating is described along with proposed measurements related to the detection, lifetimes, and drift of artificial irregularities generated by ionospheric heating in the underdense mode. A.R.H.

N81-10541*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE RETRODIRECTIVE ARRAYS FOR SPS BEAM POINTING
Ralph Chernoff *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 79-101 ref
Avail: NTIS HC A16/MF A01 CSCL 10A

The basic requirement of the SPS beam pointing system is that it deliver a certain amount of S-band (lambda = 12.5 cm) power to a 9.6 km diameter receiving rectenna on the ground. The power is transmitted from a 1.0 km diameter antenna array on the SPS, which is, for a rectenna at about plus or minus 40 deg. latitude, some 37.5x10 to the 6th power km distant. At the present time ARA's appear to be the best bet to realize this very stringent beam pointing requirement. An active retrodirective array (ARA) transmits a beam towards the apparent source of an illuminating signal called the pilot. The array produces, not merely reflects, RF power. Retrodirectivity is achieved by retransmitting from each element of the array a signal whose phase is the 'conjugate' of that received by the element. Phase conjugate circuits and pointing errors in ARA's are described. Results obtained using a 2-element X-band ARA and an 8-element S-band ARA are included. A.R.H.

N81-10542*# LinCom Corp., Los Angeles, Calif.
PERFORMANCE ANALYSIS AND SIMULATION OF THE SPS REFERENCE PHASE CONTROL SYSTEM
W. C. Lindsey and C. M. Chie *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 102-118 refs

Avail: NTIS HC A16/MF A01 CSCL 10A

The major elements required in the operation of an SPS which employs retrodirectivity as a means of pointing the beam to Earth include the spacetenna, the rectenna, and the pilot signal transmitter. The phase control system is faced with several problems: (1) path delay variations due to imperfect SPS circular orbits; (2) ionospheric effects; (3) initial phase beam forming; (4) beam pointing; (5) beam safing; (6) high power phase noise effects; and (7) interference. The use of SOLARISM, a computer program to select pilot signal parameters and evaluate SPS performance is described. A.R.H.

N81-10843*# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

DESIGN AND BREADBOARD EVALUATION OF THE SPS REFERENCE PHASE CONTROL SYSTEM CONCEPT

P. M. Hopkins and V. R. Rao *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 119-128 refs

(Contract NAS9-15800)
Avail: NTIS HC A16/MF A01 CSCL 10A

The total breadboard system includes one pilot transmitter, one pilot receiver, nine phase distribution units, and two power transponders. With this complement of equipment, segments of a typical phase distribution system can be assembled to facilitate the evaluation of significant system parameters. The achievable accuracy of a large phase distribution system, the sensitivity of the system to parameter variations, and the limitations of commercially available components in such applications were determined. T.M.

N81-10844*# LinCom Corp., Los Angeles, Calif.

COHERENT MULTIPLE TONE TECHNIQUE FOR GROUND BASED SPS CONTROL

C. M. Chie *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1981 p 129-138 refs
(Contract NAS9-15782)
Avail: NTIS HC A16/MF A01

The control system achieves beam forming by adjusting the phases of the individual transmitters onboard the solar power satellite. To specify the correct amount of adjustments, the phases of the power beams from each individual transmitter arriving at the rectenna center are measured, the appropriate corrections determined, and then relayed to the satellite. The functional operation of the ground based phase control concept is summarized. The key issues examined were: measurement waveform design and selection; phase measurement pilot reference design and selection; uplink phase corrections command link format and design; and system synchronization techniques. T.M.

N81-10845*# Nowar Electronics Corp., Barberton, Ohio.

AN INTERFEROMETER-BASED PHASE CONTROL SYSTEM

James H. Ott and James S. Rice *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1981 p 139-140 refs

Avail: NTIS HC A16/MF A01 CSCL 10A

A system for focusing and pointing the SPS power beam is discussed. The system is ground based and closed loop. One receiving antenna is required on earth. A conventional uplinked data channel transmits an 8-bit phase error correction back to the SPS for sequential calibration of each power module. Beam pointing resolution is better than 140 meters at the rectenna. T.M.

N81-10853*# Raytheon Co., Lexington, Mass.

THE ADAPTING OF THE CROSSED-FIELD DIRECTIONAL AMPLIFIER TO THE REQUIREMENTS OF THE SPS Progress Report

William C. Brown *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 214-222 refs

Avail: NTIS HC A16/MF A01 CSCL 10A

Progress was reviewed with special emphasis upon recent developments in controlling the phase and amplitude of the microwave power output, and a perceived architecture for its placement in the subarray. Development in the critical pivotal areas of noise, potential cathode life, and efficiency are reported. T.M.

N81-10854*# Boeing Aerospace Co., Seattle, Wash.

REFERENCE SYSTEM DESCRIPTION

C. D. Lunden, W. W. Lund, and E. J. Nalos *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 227-234

Avail: NTIS HC A16/MF A01 CSCL 10A

Several candidate antenna configurations are evaluated in terms of weight, efficiency, and structural rigidity. Particular emphasis is given to the waveguide slot array and its application to solar power satellites SPS. The electronic aspects of an SPS specific waveguide slot array are defined. R.C.T.

N81-10856*# Raytheon Co., Lexington, Mass.

METHOD FOR PRECISION FORMING OF LOW-COST, THIN-WALLED SLOTTED WAVEGUIDE ARRAYS FOR THE SPS

William C. Brown *In* NASA. Johnson Space Center Power Satellite Microwave Transmission and Reception Dec. 1980 p 253-255
Avail: NTIS HC A16/MF A01 CSCL 10A

A method for the precision forming of thin walled, slotted waveguide arrays was devised. Models were constructed with temporary tools and evaluated. The application of the method to the solar power satellite requirements was investigated. R.C.T.

N81-10857*# Georgia Inst. of Tech., Atlanta. Engineering Experiment Station.

CONSIDERATION FOR HIGH ACCURACY RADIATION EFFICIENCY MEASUREMENTS FOR THE SOLAR POWER SATELLITE (SPS) SUBARRAYS

D. J. Kozakoff, J. M. Schuchardt, and C. E. Ryan *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 256-267 refs

(Contract NAS8-33605)
Avail: NTIS HC A16/MF A01 CSCL 10A

The transmit beam and radiation efficiency for 10 metersquare subarray panels were quantified. Measurement performance potential of far field elevated and ground reflection ranges and near field technique were evaluated. The state-of-the-art of critical components and/or unique facilities required was identified. Relative cost, complexity and performance tradeoffs were performed for techniques capable of achieving accuracy objectives. It is considered that because of the large electrical size of the SPS subarray panels and the requirement for high accuracy measurements, specialized measurement facilities are required. Most critical measurement error sources have been identified for both conventional far field and near field techniques. Although the adopted error budget requires advances in state-of-the-art of microwave instrumentation, the requirements appear feasible based on extrapolation from today's technology. Additional performance and cost tradeoffs need to be completed before the choice of the preferred measurement technique is finalized. R.C.T.

N81-10858*# Raytheon Co., Waltham, Mass. New Products Center.

THE HISTORY OF THE DEVELOPMENT OF THE RECTENNA

William C. Brown *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 271-280 refs

Avail: NTIS HC A16/MF A01 CSCL 10A

The history of the development of the rectenna is reviewed through its early conceptual developmental phases. Some selective aspects of the current solar power satellite rectenna development are examined. R.C.T.

N81-10859*# Boeing Aerospace Co., Seattle, Wash.

RECTENNA SYSTEM DESIGN

G. R. Woodcock and R. W. Andryczyk (General Electric Co.) *In* NASA. Johnson Space Center Solar Power Satellite Microwave

Transmission and Reception Dec. 1980 p 281-290

Avail: NTIS HC A16/MF A01 CSCL 10A

The fundamental processes involved in the operation of the rectenna system designed for the solar power satellite system are described. The basic design choices are presented based on the desired microwave rf field concentration prior to rectification and based on the ground clearance requirements for the rectenna structure. A nonconcentrating inclined planar panel with a 2 meter minimum clearance configuration is selected as a representative of the typical rectenna. R.C.T.

N81-10882*# Jet Propulsion Lab., California Inst. of Tech., Pasadena. Telecommunications Science and Engineering Div.
RECTENNA ARRAY MEASUREMENT RESULTS
Richard M. Dickinson *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 307-318 refs

Avail: NTIS HC A16/MF A01 CSCL 10A

The measured performance characteristics of a rectenna array are reviewed and compared to the performance of a single element. It is shown that the performance may be extrapolated from the individual element to that of the collection of elements. Techniques for current and voltage combining are demonstrated. The array performance as a function of various operating parameters is characterized and techniques for overvoltage protection and automatic fault clearing in the array are demonstrated. A method for detecting failed elements also exists. Instrumentation for deriving performance effectiveness is described. Measured harmonic radiation patterns and fundamental frequency scattered patterns for a low level illumination rectenna array are presented. M.G.

N81-10883*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MICROWAVE POWER TRANSMISSION SYSTEM WORKSHOP, SESSION ON SOLID STATE
Woolsey Finnell *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 323-327
Avail: NTIS HC A16/MF A01 CSCL 10A

The development of solid state technology for solar power satellite systems is briefly addressed. The economic advantages of solid state based systems are listed along with some conclusions and issues regarding specific design concepts. M.G.

N81-10884*# Boeing Aerospace Co., Seattle, Wash.
MODIFIED REFERENCE SPS WITH SOLID STATE TRANSMITTING ANTENNA
G. R. Woodcock and B. R. Sperber *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 328-337

Avail: NTIS HC A16/MF A01 CSCL 10A

The development of solid state microwave power amplifiers for a solar power satellite transmitting antenna is discussed. State-of-the-art power-added efficiency, gain, and single device power of various microwave solid state devices are compared. The GaAs field effect transistors and the Si-bipolar transistors appear potentially feasible for solar power satellite use. The integration of solid state devices into antenna array elements is examined and issues concerning antenna integration and consequent satellite configurations are examined. M.G.

N81-10885*# Boeing Aerospace Co., Seattle, Wash.
SPS SOLID STATE ANTENNA POWER COMBINER
G. W. Fitzsimmons *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 338-347
Avail: NTIS HC A16/MF A01 CSCL 10A

A concept for a solar power satellite antenna power combiner which utilizes solid state dc-rf converters is described. To avoid the power combining losses associated with circuit hybrids it is proposed that the power from multiple solid state amplifiers be combined by direct coupling of each amplifier's output to the radiating antenna structure. The selected power-combining antenna consists of a printed (metalized) microstrip circuit on a ceramic type dielectric substrate which is backed by a shallow lightweight aluminum cavity which sums the power of four microwave sources. The antenna behaves like two one-half wavelength slot-line antennas coupled together via their common cavity structure. A significant feature of the antenna configuration selected is that the radiated energy is summed to yield a single radiated output phase which represents the average insertion phase of the four power amplifiers. This energy may be sampled and, by comparison with the input signal, one can phase error correct to maintain the insertion phase of all solid state power combining modules at exactly the same value. This insures that the insertion phase of each SPS power combining antenna module is identical. An experiment verification program is described. M.G.

N81-10886*# Rockwell International Corp., Pittsburgh, Pa.
SOLID STATE SYSTEMS CONCEPTS
I. K. Schroeder *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 348-357
Avail: NTIS HC A16/MF A01 CSCL 10A

Two prototype solid state phased array systems concepts for potential use in the Solar Power Satellite are described: the end-mounted and the sandwich systems. In both concepts, the beam is centered on the rectenna by means of phase conjugation of a pilot signal emanating from the ground. In the end-mounted system 38-watt amplifiers are mounted on the ground-plane, whereas in the sandwich the amplifiers are elevated to the dipoles, and their waste heat is dissipated by beryllium oxide discs. The feed lines are underneath the ground-plane, and a coaxial transmission line is carried all the way to the amplifier input. Also discussed is solid state amplifier development. M.G.

N81-10887*# RCA Corp., Princeton, N. J.
SOLID STATE DEVICE TECHNOLOGY FOR SOLAR POWER SATELLITE
David G. Weir *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 358-366
Avail: NTIS HC A16/MF A01 CSCL 10A

The feasibility of using solid state elements in the solar power satellite transmitter system is addressed. Recommendations are given concerning device types, the antenna modules, and the overall antenna system. The development of a solid state amplifier based on GaAs field effect transistor devices is also described. M.G.

N81-10888*# Raytheon Co., Waltham, Mass. Equipment Div.
SOLID STATE SANDWICH CONCEPT: DESIGNS, CONSIDERATIONS AND ISSUES Progress Report
Owen E. Maynard *In* NASA. Johnson Space Center Solar Power Satellite Microwave Transmission and Reception Dec. 1980 p 367-372
Avail: NTIS HC A16/MF A01 CSCL 10A

Progress in analysis and design of solid state approaches to the solar power satellite microwave power transmission system is reviewed with special emphasis on the Sandwich concept and the issues of maintenance of low junction temperatures for amplifiers to assure acceptable lifetime. Ten specific issues or considerations are discussed and their resolution or status is presented. Author

N81-10889# Aerospace Corp., El Segundo, Calif.
MAGNETOSPHERIC EFFECTS OF ION AND ATOM INJECTIONS BY THE SATELLITE POWER SYSTEM Final Report
Y. T. Chiu, J. G. Luhmann, M. Schulz, and J. M. Cornwall (UCLA) Argonne, Ill. ANL Jul. 1980 119 p refs
(Contract W-31-109-eng-38)
(ANL/EES-TM-94; SSL-80(9990)-1) Avail: NTIS HC A06/MF A01

A two year assessment of magnetospheric effects of the construction and operation of a satellite power system is reported. This assessment effort is based on application of present scientific knowledge rather than on original scientific research. Mass and energy injections of the system are sufficient to modify the magnetosphere substantially, to the extent of possibly requiring mitigation measures for space systems but not to the extent of causing major redirection of efforts and concepts. The scale of the SPS is so large, that these impressions require verification (or rejection) by in-depth assessment based on original scientific treatment of the principal issues. Approximate limits of magnetospheric modifications are defined. Modifications of the space radiation environment, of the atmospheric airglow background, of the auroral response to solar activity and of the fluctuations in space plasma density are identified as the principal impacts. S.F.

N81-19490*# Raytheon Co., Waltham, Mass. Microwave and Power Tube Div.
SATELLITE POWER SYSTEM (SPS) MAGNETRON TUBE ASSESSMENT STUDY
William C. Brown Feb. 1981 184 p refs
(Contract NAS8-33157)
(NASA-CR-3383; M-331) Avail: NTIS HC A09/MF A01 CSCL 10A

The data base was extended with respect to the magnetron directional amplifier and its operating parameters that are pertinent to its application in the solar power satellite. On the basis of the resulting extended data base the design of a magnetron was outlined that would meet the requirements of the SPS application and a technology program was designed that would result in its development. The proposed magnetron design for the SPS is a close scale of the microwave oven magnetron, and resembles it closely physically and electrically. T.M.

N81-19493*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SOLAR POWER SATELLITE SYSTEM SIZING TRADEOFFS
G. D. Arndt and L. G. Monford Feb. 1981 44 p ref
(NASA-TP-1804; S-505) Avail: NTIS HC A03/MF A01 CSCL 10A

Technical and economic tradeoffs of smaller solar power satellite systems configured with larger antennas, reduced output power, and smaller rectennas, are considered. The differential costs in electricity for seven antenna/rectenna configurations operating at 2.45 GHz and five satellite systems operating at 5.8 GHz are calculated. Two 2.45 GHz configurations dependent upon the ionospheric power density limit are chosen as examples. If the ionospheric limit could be increased to 54 mW sq/cm from the present 23 mW sq/cm level, a 1.53 km antenna satellite operating at 2.45 GHz would provide 5.05 GW of output power from a 6.8 km diameter rectenna. This system gives a 54 percent reduction in rectenna area relative to the reference solar power satellite system at a modest 17 percent increase in electricity costs. At 5.8 GHz, an 0.75 km antenna providing 2.72 GW of power from a 5.8 km diameter rectenna is selected for analysis. This configuration would have a 67 percent reduction in rectenna area at a 36 percent increase in electricity costs. Ionospheric, atmospheric, and thermal limitations are discussed. Antenna patterns for three configurations to show the relative main beam and sidelobe characteristics are included. A.R.H.

N81-19562*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SATELLITE POWER STUDY (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). VOLUME 1: EXECUTIVE SUMMARY Final Report
G. M. Hanley Washington NASA Mar. 1981 50 p refs
(Contract NAS8-32475)
(NASA-CR-3392; SSD-80-0108-1) Avail: NTIS HC A03/MF A01 CSCL 10A

Efforts concentrated on updating of the Rockwell reference concept, definition of new system options, studies of special emphasis topics, further definition of the transportation system, and further program definition. The Rockwell reference satellite concept has a gallium arsenide (GaAs) solar cell array having flat concentrators with an effective concentration ratio of 1.83 at end of life. Alternatives to this concept includes solid state power amplifiers or magnetrons for dc/RF conversion and multibandgap solar cells for solar to dc energy conversion. Two solid state concepts were studied. It was determined that the magnetron approach was the lowest mass and cost system. T.M.

N81-19564*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS). LSST SYSTEMS AND INTEGRATION TASK FOR SPS FLIGHT TEST ARTICLE Final Report
H. S. Greenberg Washington NASA Feb. 1981 142 p refs
(Contract NAS8-32475)
(NASA-CR-3378; SSD-80-0102) Avail: NTIS HC A07/MF A01 CSCL 10A

This research activity emphasizes the systems definition and resulting structural requirements for the primary structure of two potential SPS large space structure test articles. These test articles represent potential steps in the SPS research and technology development. Author

N81-19565*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). VOLUME 3: TRANSPORTATION ANALYSIS Final Report
G. M. Hanley Washington NASA Mar. 1981 85 p refs
(NAS8-32475)
(NASA-CR-3394; SSD-80-0108-3) Avail: NTIS HC A05/MF A01 CSCL 10A

Additional analyses and investigations were conducted to further define transportation system concepts that will be needed for the developmental and operational phases of an SPS program. To accomplish these objectives, transportation systems such as the Shuttle and its derivatives were identified; new heavy lift launch vehicle (HLLV) concepts, cargo and personnel orbital transfer vehicles (EOTV and POTV), and intraorbit transfer vehicle (IOTV) concepts were evaluated; and, to a limited degree, the program implications of their operations and costs were assessed. The results of these analyses were integrated into other elements of the overall SPS concept definition studies. T.M.

N81-19566*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). VOLUME 4: OPERATIONS ANALYSES Final Report
G. M. Hanley Washington NASA Mar. 1981 103 p refs
(Contract NAS8-32475)
(NASA-CR-3395; SSD-80-0108-4) Avail: NTIS HC A06/MF A01 CSCL 10A

Using a coplanar, end-mounted antenna as a baseline, various configuration trades were performed to select a preferred solid state concept. The increase in efficiency that could be realized by use of multi bandgap solar cells, either with klystron or solid state antenna was evaluated. Satellite configurations were developed to exploit the sandwich antenna concept wherein solar cells are located on one side of the antenna panel and solid state dc/RF converters on the other side. These concepts entailed various primary and secondary reflector arrangements for directing solar energy to the solar cell side of the antenna with higher concentration ratios than used on the coplanar configurations. Operations analysis included development of a satellite construction scenario, a concept for the SCB, a top-level satellite construction operation, construction operation, construction timelines and crew sizes, mass flows to orbit, and a satellite maintenance scenario. The list of materials required for satellite construction was updated to identify significant differences relevant to the solid state satellite concept. Means of decommissioning satellites at the end of their design life were studied. A.R.H.

N81-19602# Rice Univ., Houston, Tex.
SATELLITE POWER SYSTEM (SPS). RECTENNA SITING: AVAILABILITY AND DISTRIBUTION OF NOMINALLY ELIGIBLE SITES
Nov. 1980 283 p refs
(Contract DE-AC01-79ER-10041)
(DOE/ER-10041/T10) Avail: NTIS HC A13/MF A01

Siting of 60 ground receiving stations (rectennas) for the SPS may pose a problem due to the large area per rectenna (15,000 hectares, 38,000 acres) and numerous siting constraints. This study analyzes areas potentially eligible for rectenna sites by mapping, at a national scale, those conditions which would preclude rectenna construction. These exclusion variables which reflect restricted lands, topography, safety, national policy and electromagnetic (microwave) effects, were computer encoded and tabulated. Subsequent analysis of the nine electric power planning regions that make up the contiguous states indicate an apparently adequate number of nominally eligible sites in all regions in comparison to projected electrical generation. DOE

N81-19910*# Battelle Columbus Labs., Ohio.
SATELLITE POWER SYSTEMS (SPS) SPACE TRANSPORTATION COST ANALYSIS AND EVALUATION
Nov. 1980 141 p refs Sponsored by NASA
(Contract W-31-109-eng-38)
(NASA-CR-164020; DOE/ER-0086) Avail: NTIS HC A07/MF A01 CSCL 22B

A picture of Space Power Systems space transportation costs at the present time is given with respect to accuracy as stated, reasonableness of the methods used, assumptions made, and uncertainty associated with the estimates. The approach used consists of examining space transportation costs from several perspectives to perform a variety of sensitivity analyses or reviews and examine the findings in terms of internal consistency and external comparison with analogous systems. These approaches are summarized as a theoretical and historical review including a review of stated and unstated assumptions used to derive the costs, and a performance or technical review. These reviews cover the overall transportation program as well as the individual vehicles proposed. The review of overall cost assumptions is the principal means used for estimating the cost uncertainty derived. The cost estimates used as the best current estimate are included. DOE

N81-19962*# Environmental Protection Agency, Research Triangle Park, N.C.
ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM-CONCEPT DEVELOPMENT AND EVALUATION PROGRAM-MICROWAVE HEALTH AND ECOLOGICAL EFFECTS
Nov. 1980 146 p refs Sponsored by NASA
(Contract DE-AT01-79ER-10035)
(NASA-CR-164021; DOE/ER-10035/2) Avail: NTIS HC A07/MF A01 CSCL 13B

Potential health and ecological effects of the microwave beam from the microwave power transmission system (MPTS) of the satellite power system (SPS) are discussed. A detailed critical review of selected scientific articles from the published literature on the biological effects of nonionizing electromagnetic radiation is provided followed by an assessment of the possible effects of the SPS, based on exposure values for the reference system. DOE

N81-20328*# Nower Electronics Corp., Barberton, Ohio.
A THEORETICAL STUDY OF MICROWAVE BEAM ABSORPTION BY A RECTENNA Final Report
James H. Ott, James S. Rice, and Donald C. Thorn 14 Jan. 1981 133 p refs
(Contract NAS8-18055)
(NASA-CR-160921) Avail: NTIS HC A07/MF A01 CSCL 20N

The theoretical operational parameters for the workable satellite power system were examined. The system requirements for efficient transmission and reception of an environmentally benign microwave beam were determined.

N81-20329*# Nower Electronics Corp., Barberton, Ohio.
A THEORETICAL STUDY OF MICROWAVE BEAM ABSORPTION BY A RECTENNA, INTRODUCTION
In its A Theoret. Study of Microwave Beam Absorption by a Rectenna 14 Jan. 1981 p 1-36 refs (For primary document see N81-20328 11-32)
Avail: NTIS HC A07/MF A01 CSCL 20N

The conditions required for a large rectenna array (i.e., reference design) to absorb nearly 100% of transmitted energy were studied. Design parameters including element spacing, and the manner in which these affect scatter were formulated. Amplitudes and directions of scatter and development of strategies for mitigation were also investigated. The effects on rectenna behavior of external factors such as weather and aircraft overflights were determined. R.C.T.

N81-20335*# Nower Electronics Corp., Barberton, Ohio.
TROPOSPHERIC/IONOSPHERIC TRANSMISSION TESTS
In its A Theoret. Study of Microwave Beam Absorption by a Rectenna 14 Jan. 1981 p 111-118

Avail: NTIS HC A07/MF A01 CSCL 20N

Four tests are described which are designed to evaluate the magnitude, type, and frequency of occurrence of amplitude and phase variations in the solar power satellite power (SPS) beam as seen by the rectenna. Particular attention is given to the degree of deviation in the propagation observed under two conditions unique to the SPS: monochromaticity; and smallness of the effective aperture of individual rectenna element dipoles. R.C.T.

N81-20340# SRI International Corp., Menlo Park, Calif. Remote Measurements Lab.
MEASUREMENTS OF POSSIBLE D- AND E-REGION TELECOMMUNICATIONS EFFECTS DURING IONOSPHERIC HEATING Final Report
R. L. Showen Feb. 1980 35 p refs
(Contract DE-AI01-80ER-10180; SRI Proj. 8595)
(DOE/ER-10181/1) Avail: NTIS HC A03/MF A01

Measurements were made of the effects that heating the ionosphere might have on the passage of radiowaves through the D and E regions. The effects of the solar power satellite microwave power beam on the lower ionosphere were simulated. The increased electron temperatures produced by a HF ionospheric heater caused cross modulation on certain radiowaves when the heater was rapidly modulated (the Luxembourg effect). Small amounts of cross modulation were detected at four frequencies between 60 kHz and 5 MHz. Attempts were made to detect phase path changes indicative of electron number density changes while the heater was slowly cycled on and off. No phase path changes was observed for radiowaves of frequency 10.2 or 60 kHz. If these results are extrapolated to the powers and frequency of the solar power satellite power beam, then no significant impact from D and E region modification on telecommunications services are expected. DOE

N81-20637*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). VOLUME 6, PART 1: COST AND PROGRAMMATICS Final Report
G. M. Hanley Washington NASA Mar. 1981 84 p refs
(Contract NAS8-32475)
(NASA-CR-3397; SSD-80-0108-6-1) Avail: NTIS HC A05/MF A01 CSCL 10A

A summary of the cost data reviewed as well as conclusions and recommendations are presented. Cost and programmatic aspects of Rockwell's SPS CR-2 reference configuration were based on the results of several contracts with NASA and independent company-sponsored activities by the Space Operations and Satellite Systems Division of Rockwell International. T.M.

N81-20866# PRC Energy Analysis Co., Los Angeles, Calif.
SATELLITE POWER SYSTEM (SPS) UTILITY INTEGRATION: INSTITUTIONAL, PLANNING AND OPERATIONAL ISSUES
Meredith Crist, John Hill, Allen D. Kotin, and James A. Rabe Oct. 1980 205 p refs
(Contract DE-AC01-79ER-10041)
(EAC-R-4015) Avail: NTIS HC A10/MF A01

Management and organizational arrangements are needed to incorporate 300 GW of Satellite Power System (SPS) electrically into the US utility grid. Locating a sufficient number of suitable rectenna sites in the eastern United States to serve projected load centers on a proportional basis appears to be difficult. Transmission distances from rectennas to load centers could be a problem in the western United States. Long transmission distances are undesirable from a technical point of view but can be managed. More significant is the fact that long transmission lines associated with SPS would consistently cross state (and other regulatory) boundaries. However, siting exercises suggest that 60 rectennas could be located in eligible areas within the continental United States to serve projected load centers without violating the current state of the art of electricity transmission and load management. DOE

N81-20999# Argonne National Lab., Ill.
ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM CONCEPT DEVELOPMENT AND EVALUATION PROGRAM. ATMOSPHERE EFFECTS
D. M. Rote, K. L. Brubacker, and J. L. Lee Nov. 1980 128 p refs
(Contract W-31-109-eng-38)
(DOE/ER-0090) Avail: NTIS HC A07/MF A01

The issues associated with SPS activities in the troposphere were examined. These include tropospheric weather modification related to rectenna operations and rocket launches, and air quality impacts related to rocket launch ground clouds. Then progressing upward through the various levels of the atmosphere, the principal middle and upper atmospheric effects associated with rocket effluents were analyzed. Finally, all of the potential SPS atmospheric effects are summarized. DOE

N81-21401*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SATELLITE POWER SYSTEM (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). VOLUME 2: SYSTEMS/SUBSYSTEMS ANALYSES Final Report
G. M. Hanley Washington NASA Mar. 1981 338 p refs
(Contract NAS8-32475)
(NASA-CR-3393; SSD-80-0108-2) Avail: NTIS HC A15/MF A01 CSCL 10A

Modifications to the reference concept were studied and the best approaches defined. The impact of the high efficiency multibandgap solar array on the reference concept design is considered. System trade studies for several solid state concepts, including the sandwich concept and a separate antenna/solar concept, are described. Two solid state concepts were selected and a design definition is presented for each. Magnetrons as an alternative to the reference klystrons for dc/RF conversion are evaluated. System definitions are presented for the preferred klystron and solid state concepts. Supporting systems are analyzed, with major analyses in the microwave, structures, and power distribution areas. Results of studies for thermal control, attitude control, stationkeeping, and details of a multibandgap solar cell study are included. Advanced laser concepts and the meteorological effects of a laser beam power transmission concept are considered. J.D.H.

N81-21402*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). VOLUME 4, PART 2: COST AND PROGRAMMATICS APPENDIX Final Report
G. M. Hanley Washington NASA Mar. 1981 401 p 7 Vol.
(Contract NAS8-32475)
(NASA-CR-3398; SSD-80-0108-6-2) Avail: NTIS HC A18/MF A01 CSCL 10A

Cost and programmatic aspects of a recommended satellite power system are documented. Computer generated summaries are presented, and the detailed computer runs structured in a Work Breakdown Structure are given. The six configurations developed during the study period are summarized. J.D.H.

N81-21534*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY (EXHIBIT D). SOLID-STATE AMPLIFIER INVESTIGATION Final Report
G. M. Hanley Washington NASA Apr. 1981 102 p refs
(Contract NAS8-32475)
(NASA-CR-3400; SSD-80-0120) Avail: NTIS HC A06/MF A01 CSCL 10A

Data resulting from a continuing effort to provide system/subsystem definition data to aid in the evaluation of the SPS program concept is presented. The specific data described relate to the proposed use of solid state devices as microwave power amplifiers in the satellite microwave power transmission subsystem. R.C.T.

N81-21590*# PRC Energy Analysis Co., Los Angeles, Calif.
SATELLITE POWER SYSTEM (SPS) SOCIETAL ASSESSMENT
Dec. 1980 57 p refs Sponsored by NASA
(Contract DE-AC01-79ER-10041)
(NASA-CR-164153; DOE/ER-10041/T12) Avail: NTIS HC A04/MF A01 CSCL 10A

Construction and operation of a 60-unit (300 GW) domestic SPS over the period 2000 to 2030 would stress many segments of U.S. society. A significant commitment of resources (land, energy, materials) would be required, and a substantial proportion of them would have to be committed prior to the production of any SPS electricity. Forty-four concerns about the SPS were identified via a public outreach experiment involving 9000 individuals from three special interest organizations. The concerns focused on environmental impacts (particularly the effects of microwave radiation) and the centralizing tendency of the SPS on society. DOE

N81-21613# California Univ., Berkeley. Lawrence Berkeley Lab.
ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM CONCEPT DEVELOPMENT AND EVALUATION PROGRAM: NONMICROWAVE HEALTH AND ECOLOGICAL EFFECTS
Margaret R. White Nov. 1980 89 p refs
(Contract W-7405-eng-48)
(DOE/ER-0089) Avail: NTIS HC A05/MF A01

A preliminary reference system was developed. The assessment is summarized as to scope, methodology, impacts of terrestrial development, launch and recovery of spacecraft, space activities (including health effects of the space environment, ionizing radiation, electromagnetic exposure, spacecraft charging and environmental interactions, occupational hazards, etc.) and construction and operation of rectenna (ground receiving station). DOE

N81-21642# Battelle Pacific Northwest Labs., Richland, Wash.
ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM CONCEPT DEVELOPMENT AND EVALUATION PROGRAM-ELECTROMAGNETIC
K. A. Davis, W. B. Grant, E. L. Morrison, and J. R. Juroshek Jan. 1981 93 p refs Prepared in cooperation with Institute for Telecommunication Sciences
(Contract DE-AC06-76RL-01830)
(DOE/ER-0098) Avail: NTIS HC A05/MF A01

An initial quantitative indication of the scope of potential electromagnetic compatibility (EMC) problems is provided and the importance of EMC considerations in rectenna site selection are indicated. The effects of satellite power system (SPS) microwave emissions on important categories of electronic systems and equipment are summarized, with many examples of test results and demonstrated techniques for mitigation of problems encountered. The SPS effects on other satellite systems are presented. Astronomical research frequently involves measurement of extremely low levels of electromagnetic radiation and is thus very susceptible to interference. The concerns of both radio astronomy with microwave emissions from SPS and optical astronomy with sunlight scattered from SPS spacecraft are discussed. Summaries of mitigation techniques, cost estimates, and conclusions are presented. DOE

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GENERAL

Includes either state-of-the-art or advanced technology which may apply to Large Space Systems and does not fit within the previous nine categories. Shuttle payload requirements, on-board requirements, data rates, and shuttle interfaces, and publications of conferences, seminars, and workshops will be covered in this area.

A81-10496 * **Middle atmosphere NO/x/ production due to ion propulsion induced radiation belt proton precipitation.** A. C. Aikin (NASA, Goddard Space Flight Center, Laboratory for Planetary Atmospheres, Greenbelt, Md.) and C. H. Jackman (National Academy of Sciences, Washington, D.C.). *Space Solar Power Review,* vol. 1, no. 3, 1980, p. 241-243. 9 refs.

The suggestion that keV Ar(+) resulting from ion propulsion operations during solar power satellite construction could cause energetic proton precipitation from the inner radiation belt is examined to determine if such precipitation could cause significant increases in middle atmosphere nitric oxide concentrations thereby adversely affecting stratospheric ozone. It is found that the initial production rate of NO (mole/cu cm-sec) at 50 km is 130 times that due to nitrous oxide reacting with excited oxygen. However, since the time required to empty the inner belt of protons is about 1 sec and short compared to the replenishment time due to neutron decay, precipitation of inner radiation belt protons will have no adverse atmospheric environmental effect. (Author)

A81-18251 * **Space Shuttle cargo processing.** J. J. Neilon (NASA, Kennedy Space Center, Cargo Projects Office, Cocoa Beach, Fla.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-A-43.* 30 p.

The spacecraft processing techniques to be used at the Kennedy Space Center for the assembly and check-out of Space Shuttle cargoes are discussed. The processing flow for vertically handled spacecraft, which are inserted into the Shuttle orbiter cargo bay while the orbiter is in the vertical position and often are attached to a separate solid booster stage, includes assembly into unified payloads in the Vertical Processing Facility, followed by Cargo Integration Test Equipment tests to ensure cargo bay compatibility, and transportation to the launch pad. Horizontally handled spacecraft such as Spacelab, which are inserted into the Orbiter cargo bay while it is in the Orbiter Processing Facility in the horizontal position, are assembled and checked out within the Operations and Checkout Building, where the CITE tests are performed and the Spacelab will be disassembled, and then transported to the Orbiter Processing Facility. It is pointed out that during the Space Shuttle era, when the number of spacecraft to be processed simultaneously at Kennedy will double or triple, all spacecraft processing facilities will be required to handle the workload. A.L.W.

A81-18418 **Economic benefits of the OTV program.** D. A. Heald (General Dynamics Corp., Convair Div., San Diego, Calif.). *International Astronautical Federation, International Astronautical Congress, 31st, Tokyo, Japan, Sept. 22-28, 1980, Paper 80-IAA-38.* 13 p.

A new upper stage for the Shuttle called Orbiter Transfer Vehicle (OTV) is planned by NASA for a broad range of missions including transfer of very large spacecraft and unmanned and manned servicing at geosynchronous orbit (GEO). Leading OTV-configurations use 13 to 34 tons of cryogenic propellants in vehicles based on the existing Centaur or new designs. These OTVs can deliver to geosynchronous orbit more than double the payload possible with the solid propellant Inertial Upper Stage (IUS), which is currently being developed. This high performance reduces the number of shuttle launches required to deliver a given total mass of payloads. After delivery of current size spacecraft, OTV could be returned to the orbiter for reuse, saving the cost of building a newstage. OTV performance and flexibility will create the opportunity for the next generation of spacecraft such as the Geostationary Platform. In these three ways, the high-performance OTV will provide economic benefits to space transportation systems. (Author)

A81-18440 * **Technology - The path to the next 50 years.** D. P. Williams and S. R. Sadin (NASA, Washington, D.C.). *British Interplanetary Society, Journal (Space Technology),* vol. 34, Feb. 1981, p. 58-64.

The paper stresses the importance of committing time and resources to space technology based on the premise that an accurate appraisal of the impact of technology and other influences on the present state of aviation will facilitate the planning of space technology. The paper presents the technological advances in aviation since 1903 by dividing the era of aviation into four distinct segments and, by analogy, distinct phases are also seen in the evolution of space flight. One factor seen as limiting advances in space is cost. Processes in space must now be shown to be affordable; a demonstration of technological feasibility is no longer sufficient. For this reason, technology must focus on ensuring the affordability and utility of space processes. A commitment to making space affordable will yield the tools necessary to embark on future space ventures. C.R.

A81-20426 **Conference on Decision and Control, and Symposium on Adaptive Processes, 18th, Fort Lauderdale, Fla., December 12-14, 1979, Proceedings. Volumes 1 & 2.** Conference sponsored by the Institute of Electrical and Electronics Engineers. Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1979. Vol. 1, 647 p.; vol. 2, 486 p. Price of two volumes, members, $48.; nonmembers, $60.

The conference focused on control problems in computer communication systems, control of large structures, linear systems, feedback design, statistical models of images, energy conservation through automatic control, adaptive control, reliable control systems, robots, manipulators and prostheses, optical tracking, and computational methods of entire eigenstructure control. Topics included rational matrix structure, texture modeling using stochastic structures, classification and equivalence in the estimation theory, and adaptive control of distributed parameter systems. A.T.

A81-22190 **The Shuttle Pallet Satellite system - View of an industrial service for user dedicated operational research and application missions.** D. Davidts (Messerschmitt-Bölkow-Blohm GmbH, Munich, West Germany). *(American Astronautical Society, Annual Meeting, Los Angeles, Calif., Oct. 29-Nov. 1, 1979.) Journal of the Astronautical Sciences,* vol. 28, July-Sept. 1980, p. 283-298.

The Shuttle Pallet Satellite (SPAS) system envisages a family of space platforms operating in low earth up to geosynchronous orbits. The building block concept with its flexible structure allows for easy accommodation of a broad variety of instruments like telescopes, antennas, cameras and space processing facilities, etc. Non-standardized power, data-management, tele-communication and attitude control subsystems can be assembled from running production lines requiring a minimum adjustment effort only. Orbit maneuvering can be provided if required. SPAS satellites can be easily retrieved from low earth orbits, thus contributing to reduced life cycle cost for the operating agency. The SPAS concept application to different mission requirements is presented. (Author)

A81-22752 # **New roles for manned space.** C. L. Gould (Rockwell International Corp., Space Operations and Satellite Systems Div., Downey, Calif.). *American Institute of Aeronautics and Astronautics, Conference on Large Space Platforms: Toward Permanent Manned Occupancy of Space, 2nd, San Diego, Calif., Feb. 2-4, 1981, Paper 81-0435.* 9 p.

Most of the studies done in America on space stations over the last 20 years are based on the premise that research and development is the primary role of a manned space station. This paper suggests several new roles for a permanent manned space facility: space construction base, orbital transfer vehicle depot, satellite maintenance and repair facility, spare satellite quick-deployment depot, space observatory, earth observation platform, global weather station, environment and resource base, world information processing center, space factory, and space equipment test facility. (Author)

A81-24826 * **Changes in the terrestrial atmosphere-ionosphere-magnetosphere system due to ion propulsion for solar power satellite placement.** S. A. Curtis and J. M. Grebowsky (NASA, Goddard Space Flight Center, Laboratory for Planetary Atmospheres, Greenbelt, Md.). *Space Solar Power Review*, vol. 1, no. 4, 1980, p. 269-273. 26 refs.

In order to construct solar power satellites using earth-based materials, sections of a satellite must be lifted from low earth to geosynchronous orbit. The most plausible method of accomplishing this task is by means of ion propulsion based on the relatively abundant terrestrial atmospheric component, Ar. The proposed propulsion system will release a dense beam of about 5 keV Ar(+). The total amount of Ar(+) injected in transporting the components for each solar power satellite is comparable to the total ion content of the ionosphere-plasmasphere system while the total energy injected is larger than that of this system. Preliminary estimates are given of the effects massive Ar(+) injections have on the ionosphere-plasmasphere system with specific emphasis on potential communications disruptions. The effects stem from direct Ar(+) precipitation into the atmosphere and from Ar(+) beam induced precipitation of MeV radiation belt protons. (Author)

A81-29428 **Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2.** Conferences sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, Inc., 1981. 849 p. Price of two parts, members, $75.; nonmembers, $100.

Topics discussed include: finite element prediction of damping in structures with constrained viscoelastic layers, analytical tolls for simulating large amplitude propellant slosh, static and dynamic characteristics of large deployable space reflectors, Space Shuttle main engine nozzle-steerhorn dynamics, and vibroacoustic modeling for the Space Shuttle Orbiter thermal protection system. Also discussed are attenuation of propeller-related vibration and noise, vibration of cylindrical shells of bimodulus composite materials, the automated application of Ibrahim's time-domain method to responses of the Space Shuttle, a least-squares time-domain method for simultaneous identification of vibration parameters from multiple free-response records, electronic damping of resonances in gimbal structures, and the response of stiffened sandwich panels. Also covered are a self-adaptive algorithm for thermoviscoplasticity, dynamic flight load charts for spacecraft design, nonlinear dynamic phenomena in the Space Shuttle thermal protection system, the application of transonic codes to flutter analysis of conventional and supercritical airfoils, the effect of store aerodynamics on wing/store flutter, in-flight structural dynamic characteristics of the XV-15 tilt rotor research aircraft, and the response characteristics of a linear rotorcraft vibration model. O.C.

N81-18080# Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div.

P78-2 SCATHA PRELIMINARY DATA ATLAS

E. G. Mullen, H. B. Garrett, D. A. Hardy, and E. C. Whipple (California Univ. at San Diego, La Jolla) 11 Aug. 1980 42 p refs
(AF Proj. 7661)
(AD-A094122; AFGL-TR-80-0241; AFGL-ERP-712) Avail: NTIS HC A03/MF A01 CSCL 20/8

A preliminary study of the 100 eV to approx. 1 MeV plasma environment encountered by the P78-2 Spacecraft Charging at High Altitudes (SCATHA) Satellite during its initial operation period was conducted. Forty-four days of 10 min averages of the four moments of the electron and low distribution functions calculated from the SC 5 and SC 9 energetic particle measurements were analyzed to determine occurrence frequency, local time variation, geomagnetic activity variation, and L shell variation. The single and double Maxwellian parameters derived from the four moments were similarly analyzed. The interrelationships between the moments and derived parameters were computed and the results compared with the ATS 5 and ATS 6 atlas of Garrett et al (1980). Results of this analysis establish a baseline range for the SCATHA plasma environment. GRA

N81-19180*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

LARGE SPACE SYSTEMS TECHNOLOGY, 1980, VOLUME 1

Frank Kopriver, III, comp. Feb. 1981 445 p refs Presented at the 2nd Ann. Tech. Rev., Hampton, Va., 18-20 Nov. 1980
(NASA-CP-2168; L-14219-Vol-1) Avail: NTIS HC A19/MF A01 CSCL 22B

The technological and developmental efforts in support of the large space systems technology are described. Three major areas of interests are emphasized: (1) technology pertient to large antenna systems; (2) technology related to large space systems; and (3) activities that support both antenna and platform systems.

N81-19181*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

SPACE PLATFORM ADVANCED TECHNOLOGY STUDY

G. C. Burns *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 229-242
Avail: NTIS HC A19/MF A01 CSCL 22B

The development of mechanical systems for space platforms which have universal application regardless of what platform configuration is built is discussed. The design requirements and fabrication of the orbiter berthing systems, berthing latch interface, berthing umbilical interface, and adaptive end effector are described. M.G.

N81-19182*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.

A DOCUMENT DESCRIBING SHUTTLE CONSIDERATIONS FOR THE DESIGN OF LARGE SPACE STRUCTURES

John A. Roebuck, Jr. *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 243-258 ref
Avail: NTIS HC A19/MF A01 CSCL 22B

A Shuttle user guide document to aid designers and analysis associated with large space structures projects is described. The format and contents are a compromise designed to satisfy the needs of several levels of users. Special features include checklists and references to source documents as a convenience to very knowledgeable readers. In addition, general, introductory and explanatory text, and art work are included for the reader less familiar with shuttle systems. Also, there are a subject index, glossary, list of acronyms, and many cross references. Throughout the document, there are suggested implications or references to the importance of the included orbiter interfaces material as it pertains to designing and planning large space structures projects. The content of the document is outlined. Shuttle payload accommodations and constraints, connections for orbiter construction fixtures, packaging, and construction space-geometry are addressed. M.G.

N81-19184*# Systems Science and Software, La Jolla, Calif.

ELECTROSTATIC ANTENNA SPACE ENVIRONMENT INTERACTION STUDY

Ira Katz *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 271-278
Avail: NTIS HC A19/MF A01 CSCL 22B

The interactions of the electrostatic antenna with the space environment in both low Earth orbit and geosynchronous orbit are investigated. It is concluded that the electrostatically controlled membrane mirror is a viable concept for space applications. However, great care must be taken to enclose the high voltage electrodes in a Faraday cage structure to separate the high voltage region from the ambient plasma. For this reason, metallized cloth is not acceptable as a membrane material. Conventional spacecraft charging at geosynchronous orbit should not be a problem provided ancillary structures (such as booms) are given nonnegligible conductivity and adequate grounding. Power loss due to plasma electrons entering the high field region is a potentially serious problem. In low earth orbit any opening whatever in the Faraday cage is likely to produce an unacceptable power drain. M.G.

N81-19186*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ENVIRONMENTAL EFFECTS AND LARGE SPACE SYSTEMS
H. B. Garrett *In* NASA. Langley Research Center Large Space Systems Technol., 1980, Vol. 1 Feb. 1981 p 279-286

Avail: NTIS HC A18/MF A01 CSCL 22B

When planning large scale operations in space, environmental impact must be considered in addition to radiation, spacecraft charging, contamination, high power and size. Pollution of the atmosphere and space is caused by rocket effluents and by photoelectrons generated by sunlight falling on satellite surfaces even light pollution may result (the SPS may reflect so much light as to be a nuisance to astronomers). Large (100 Km 2) structures also will absorb the high energy particles that impinge on them. Altogether, these effects may drastically alter the Earth's magnetosphere. It is not clear if these alterations will in any way affect the Earth's surface climate. Large structures will also generate large plasma wakes and waves which may cause interference with communications to the vehicle. A high energy, microwave beam from the SPS will cause ionospheric turbulence, affecting UHF and VHF communications. Although none of these effects may ultimately prove critical, they must be considered in the design of large structures. A.R.H.

N81-20949*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SCIENTIFIC AND TECHNICAL INFORMATION OUTPUT OF THE LANGLEY RESEARCH CENTER FOR CALENDAR YEAR 1980
Feb. 1981 245 p
(NASA-TM-81980) Avail: NTIS HC A11/MF A01 CSCL 05B

This document is a compilation of the scientific and technical information that the Langley Research Center has produced during the calendar year 1980. Approximately 1400 citations are given. Formal reports, quick-release technical memorandums, contractor reports, journal articles, meeting/conference papers, computer programs, tech briefs, patents, and unpublished research are included. J.M.S.

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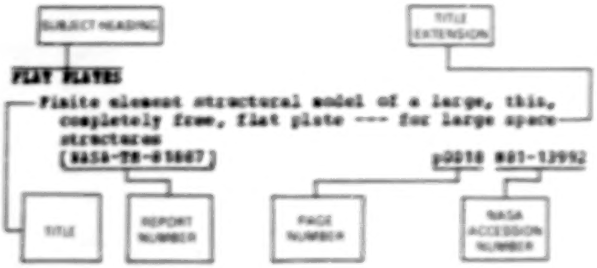

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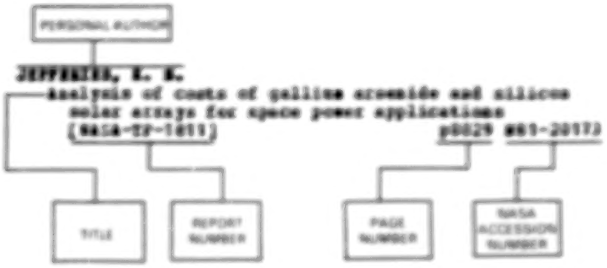
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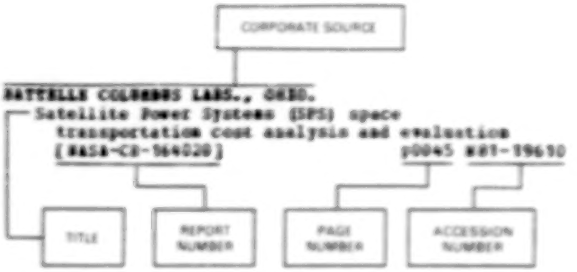
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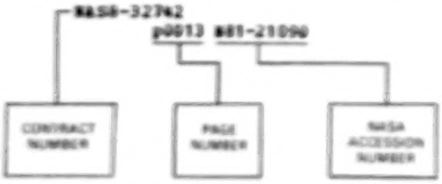

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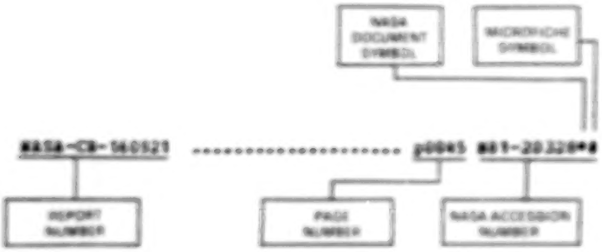

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